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Article

Euclidean Relativity Solves 15 Mysteries of Physics

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Abstract: Special and general relativity (SR/GR) describe nature from a *subjective* perspective. Mathematically, they are correct. **Here I show: (1)** Physically, SR/GR have an issue. Science should always strive for an objective description of nature. This is not possible in relative spacetime. In particular, observers cannot agree on what is past and what is future. Even so, the Lorentz factor and gravitational time dilation are correct. This is why SR/GR work so well in an observer's reality. **(2)** Euclidean relativity (ER) describes nature from an *objective* perspective. Any (!) object's proper space d_1, d_2, d_3 and its proper time τ span "natural spacetime", which is 4D Euclidean space (ES) if we take $c\tau$ as d_4. All energy is moving through ES at the speed of light c. Each observer's reality is created by projecting ES orthogonally to his proper space and to his proper time. These axes are reassembled in SR/GR to a non-Euclidean spacetime. Because information is lost in each projection, the performance of SR/GR is limited. However, the SO(4) symmetry of ES is not compatible with waves. This is fine because ER tells us that wave and particle are subjective concepts: What I deem wave packet, deems itself particle at rest. We must distinguish between an observer's reality described by SR/GR (with waves) and the "master reality" ES described by ER (without waves). ER improves cosmology and quantum mechanics by solving the Hubble tension, dark energy, and non-locality.

Keywords: spacetime; cosmology; Hubble constant; Hubble diagram; quantum mechanics

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Important Remarks

There are two different ways of how to describe nature: from the *subjective* perspective of one observer (one group of observers), or else from the *objective* perspective of any object. Special and general relativity (SR/GR) [1,2] follow the first way and describe nature subjectively. While SR and GR are mathematically correct, they have a physical issue: Observers cannot agree on a common description of nature. In either theory, spacetime is not natural, but construed from projections (see Sect 3). In each projection, information is lost. Euclidean relativity (ER) follows the second way and describes nature objectively. It takes a conceptual leap (paradigm shift) to accept ER, so be prepared.

Five pieces of advice: (1) *Do not take SR/GR as the ultimate truth.* Some reviewers made a systematic error when evaluating ER with the concepts of SR/GR. ER is different. In ER, all energy is moving at the speed of light c. (2) *Be patient and fair.* I cannot address all of physics in one paper. SR/GR have been tested for 100+ years. ER deserves the same chance. (3) *Do not be prejudiced against a theory that solves many mysteries.* New concepts often do so. (4) *Appreciate illustrations.* Geometric derivations are as good as equations. (5) *Consider that you may feel offended.* ER declares some concepts of physics obsolete.

To sum it all up: Predictions made by SR/GR are correct, but ER penetrates to a deeper level. I apologize for having prepared several preprint versions. It was tricky to figure out why SR/GR work so well in an observer's reality despite an issue. Sect. 2 is about the issue. In Sect. 3, I formulate the basic physics of ER. In Sect. 4, I recover the Lorentz factor and gravitational time dilation. In Sect. 5, ER solves 15 mysteries of physics.

1. Introduction

Today's concepts of space and time were coined by Albert Einstein. Flat spacetime in his SR is described by an indefinite distance function. SR is often interpreted in Minkowski spacetime [3], which illustrates the invariance of the spacetime interval very well. Predicting the lifetime of muons

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[4] is one example that supports SR. Curved spacetime in GR is described by a pseudo-Riemannian metric. The deflection of starlight [5] and the very high accuracy of GPS [6] are two examples that support GR. Quantum field theory [7] unifies classical field theory, SR, and quantum mechanics (QM), but not GR.

Two postulates of ER: (1) All energy is moving through 4D Euclidean space (ES) at the speed of light c. (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. My first postulate is stronger than the second postulate of SR: c is absolute and universal. My second postulate is restricted to each observer's reality rather than to inertial frames. ER also comes with a generalized concept of energy: All energy in ES is made up of quanta that may appear as wave packets and particles for different observers.

In 1969, Newburgh and Phipps introduced ER [8]. Montanus distinguished absolute from relative Euclidean spacetime (AEST, REST) [9]. AEST is ES. REST is ES in an object's reference frame (see Sect. 3). Montanus also verified gravitational lensing and the perihelion precession of elliptical orbits in ES [10,11]. He even tried to formulate electrodynamics in ES [10,11], but overlooked that the SO(4) symmetry of ES is not compatible with waves. Almeida studied geodesics in ES [12]. Gersten showed that the Lorentz transformation is an SO(4) rotation in a "mixed space" (see Sect. 3) [13]. van Linden reviews ER models [14]. Physicists still reject ER because: (1) They expect waves to be covered. (2) Dark energy and non-locality make cosmology and QM work. (3) ER faces several paradoxes if not applied properly (see Sect. 4). *This paper marks a turning point:* I disclose a physical issue in SR/GR; I explain why there are no waves in ER; 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 is moving through 3D Euclidean space as a function of an independent time. The speed of matter is $v_{3\mathrm{D}} \ll c$. In Einstein's physics, all energy is moving through 4D non-Euclidean spacetime. The speed of matter is $v_{3\mathrm{D}} < c$. In ER, all energy is moving through 4D Euclidean space. The 4D speed of all energy is $u_{4\mathrm{D}} = c$. Newton's physics [15] once inspired Kant's philosophy. Will ER reform both physics and philosophy?

2. Disclosing an Issue in Special and General Relativity

In SR [1], there are two concepts of time: subjective coordinate time t and objective proper time τ. *The fourth coordinate in SR is* t. In § 1 of SR, Einstein gives an instruction of how to synchronize clocks at P and Q. At "P time" t_P, a light pulse is sent from P to Q. At "Q time" t_Q, it is reflected. At "P time" t_P^*, it is back at P. The clocks synchronize if

$$t_\mathrm{Q} - t_\mathrm{P} = t_\mathrm{P}^* - t_\mathrm{Q} \ . \tag{1}$$

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

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

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

where K′ moves relative to K in x_1 at the constant speed $v_{3\mathrm{D}}$ and $\gamma = (1 - v_{3\mathrm{D}}^2/c^2)^{-0.5}$ is the Lorentz factor. *Mathematically,* Eqs. (1) and (2a–b) are correct for an observer R in K. There are covariant equations for an observer B in K′. *Physically,* SR has an issue. Observer R describes some event in his coordinate space x_i and coordinate time t. Observer B then describes the same event in his coordinate space x_i' and coordinate time t'. SR works well for each single observer, but there is no "master reality" (absolute reference frame), from which the reality of R and the reality of B could be deduced. R describes nature by himself, and B describes nature by himself, but R and B cannot agree on a common description of nature. In particular, they cannot agree on what is past and what is future. In GR, the issue is similar: Spacetime is parameterized, but again there is no master reality, from which the realities of all observes could be deduced.

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Why is a missing master reality a physical issue? Science should always strive for an objective description of nature. This is not possible in relative spacetime. The issue manifests itself in Sect. 5, when we use absolute 4D Euclidean space as the master reality (which includes an absolute concept of time) to solve 15 mysteries of physics.

The issue in SR/GR is very similar to the issue in the geocentric model: In either case, there is no holistic view, but just one *active* perspective. In the Middle Ages, it was natural to believe that all celestial bodies would revolve around Earth. Only the astronomers wondered about the retrograde loops of planets and claimed: Earth revolves around 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 just one active perspective. The human brain is very powerful, but unfortunately it often deems itself the center/measure of everything in the universe.

The analogy with the geocentric model is deeper than we might expect: (1) It holds despite the covariance of SR/GR. After a transformation (or else after replacing the center Earth), there is again just one *active* perspective. (2) Retrograde loops are obsolete, but only in the holistic view of the heliocentric model. Dark energy and non-locality are obsolete, but only in the holistic view of ER. (3) Just like the geocentric model, SR/GR miss the big picture. (4) In the Middle Ages, the geocentric model was considered a dogma that must not be challenged. Today, most journals do not accept submissions that challenge SR/GR. *Have physicists not learned from history? Does history repeat itself?*

3. Basic Physics of Euclidean Relativity

The indefinite distance function in SR [1] 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 $\mathrm{d}t$ and $\mathrm{d}x_i$ are distances in "coordinate spacetime" x_1, x_2, x_3, t. This spacetime is construed because all coordinates are "extrinsic concepts" (concepts that are not immanent in rulers and clocks). We may rearrange Eq. (3), so that the metric becomes Euclidean

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

where $\mathrm{d}d_i = \mathrm{d}x_i$ $(i = 1, 2, 3)$ and $\mathrm{d}d_4 = c\,\mathrm{d}\tau$ are distances in ES. In Eq. (4), the roles of t and τ have switched: The fourth coordinate in ER is an object's proper time τ (what any clock measures), and t is the new invariant "cosmic time". I keep the symbol t to stress that Eqs. (3) and (4) are equivalent. In ER, any (!) object's proper space d_1, d_2, d_3 and its proper time τ span "natural spacetime", which is ES if we take $c\tau$ as d_4. This spacetime is natural because all coordinates are "intrinsic concepts" (concepts that are immanent in rulers and clocks). The switch must not be confused with the "Wick rotation" [16], which just replaces t with it, but keeps τ as the invariant.

We are free to label the four axes of ES for each object. In an "object's reference frame" (shown in my ES diagrams), we always take d_4 as that axis in which it is moving at the speed c. These diagrams show ES from its perspective. *An object moves in its reference frame, and the axes d_1, d_2, d_3, d_4 never change for itself.* Only relative to an observer may the orientation of these axes change. An "object's reality" is created by projecting ES orthogonally to its proper space d_1, d_2, d_3 and to its proper time $\tau = d_4/c$. We specify

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

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

where $\boldsymbol{\tau}$ is the 4D vector "proper flow of time" of an object and $\boldsymbol{u}$ is its 4D velocity. The four components of $\boldsymbol{u}$ are $u_i = \mathrm{d}d_i/\mathrm{d}t$. Thus, Eq. (4) matches my first postulate

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

Thus, we could have introduced ER with my first postulate rather than with Eq. (4). Accordingly, each observer's reality is created by projecting ES orthogonally to his proper space d_1, d_2, d_3 and to his proper time $\tau = d_4/c$. These axes are set equal to x_1, x_2, x_3, t in SR (or they are parameterized in

GR) and reassembled to a non-Euclidean spacetime. It sounds tricky, but it only reflects that physics has customized space and time to observers rather than to observed objects. The twofold projection causes space and time to be treated differently in SR/GR. Because the projections are followed by setting d_1, d_2, d_3, τ equal to x_1, x_2, x_3, t (or by a parameterization), there is no continuous transition from SR/GR to ER. We do not integrate the differentials in Eq. (3). We take an object's $d_1(t), d_2(t), d_3(t), \tau(t)$ for granted rather than an observer's $x_1(\tau), x_2(\tau), x_3(\tau), t(\tau)$.

ES is the origin of each observer's reality. For this reason, I call it the "master reality". An observer's reality is unique because the axes of the projections depend on his position in ES. Spacetime in SR/GR is relative. 4D Euclidean space is absolute, but the projections to an observer's reality are relative. However, the SO(4) symmetry of ES is not compatible with waves. This is fine because ER tells us that wave and particle are subjective concepts: What I deem wave packet, deems itself particle at rest (see Sect. 5.12). We must distinguish between an observer's reality described by SR/GR (with waves) and the master reality ES described by ER (without waves). SR/GR are not included in ER although all the realities described by SR/GR are construed from the one reality described by ER.

It is instructive to contrast coordinate time t, proper time τ, and cosmic time t. Coordinate time t is an extrinsic measure of time: It is equal to $\tau = |\boldsymbol{\tau}|$ for the observer only. Proper time τ is an intrinsic measure of time: It is independent of observers. Cosmic time t is invariant and thus absolute: It is the total distance covered in ES (length of a geodesic) divided by c. By taking τ as the fourth coordinate and the parameter t as absolute time, it is possible for all observers to agree on what is past and what is future. However, time is just a subordinate quantity in ER: Only by covering distance is time passing by. Thus, I suggest to define new units for distance and speed and to measure time in these new units. In some diagrams, I project ES to an "observer's 3D space" (his proper space). We are free to label the axis of motion in his 3D space. We often take d_1 as this axis.

Let us compare SR with ER. We consider two identical clocks "r" (red clock) and "b" (blue clock). In SR, "r" is at rest: It moves only in the axis ct at $x_1 = 0$. Clock "b" starts at $x_1 = 0$, but it moves in the axis x_1 at the constant speed of $v_{3D} = 0.6\,c$. Figure 1 left shows that instant when either clock moved 1.0 s in the coordinate time of "r". Clock "b" moved 0.6 Ls (light seconds) in x_1 and 0.8 Ls in ct' (time dilation). Thus, "b" displays "0.8". ER is different: Figure 1 right shows that 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.

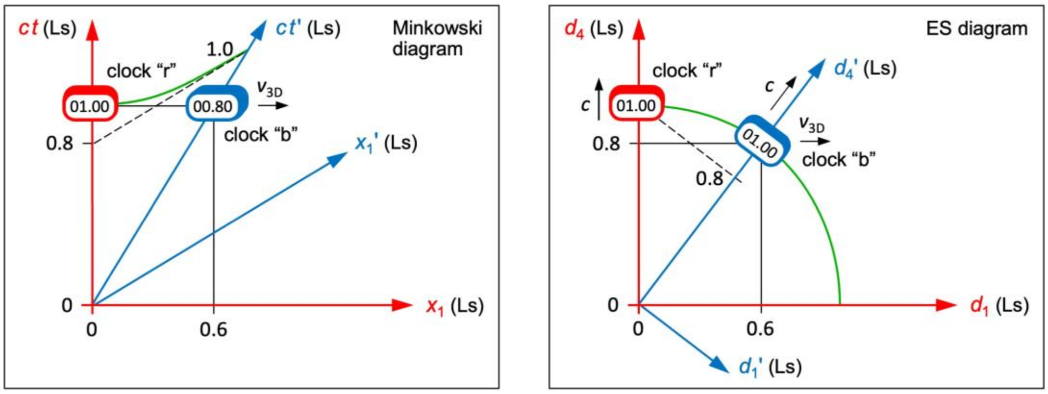

Figure 1. Minkowski diagram and ES diagram for two clocks "r" (red) and "b" (blue). **Left:** In SR, "b" is slow with respect to "r" in t'. Coordinate time is relative ("b" is not at the same positions in ct and ct'). **Right:** In ER, "b" is slow with respect to "r" in d_4. Cosmic time is absolute ("r" is in d_4 at the same position as "b" in d_4'). ER describes nature objectively. Just rotate the graph to see it!

Now watch out as this paragraph demystifies time dilation: Let observer R be with clock "r". Let observer B be with clock "b". In SR, t belongs to R and t' belongs to B. Observer R *calculates* (Lorentz transformation) that clock "b" displays $t' = 0.8$ s. Thus, "b" is slow with respect to "r" in t'. Time dilation in SR thus occurs in t', which belongs to B. In ER, d_4 belongs to R and d_4' belongs to B.

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Observer R *measures* (in his unprimed coordinate d_4) that clock "b" is at the position of $d_4 = 0.8$ Ls. Thus, "b" is slow with respect to "r" in d_4. Time dilation in ER thus occurs in d_4, which belongs to R. In SR and ER, "b" is slow with respect to "r". Coordinate time t and t' are construed coordinates, whereas proper time τ and d_4 are measurable (physical, natural) quantities.

Gersten showed that the Lorentz transformation is an SO(4) rotation in x_1, x_2, x_3, ct' [13]. He calls these coordinates "mixed space" because ct' is the only primed coordinate. Such a mixed space does not make sense physically. We may consider it another hint that the concept of coordinate spacetime in SR has a physical issue. The Lorentz transformation rotates the mixed coordinates x_1, x_2, x_3, ct' to x_1', x_2', x_3', ct. In ER, the unmixed coordinates d_1', d_2', d_3', d_4' appear rotated with respect to d_1, d_2, d_3, d_4 (see Sect. 4).

There is also a huge difference in the synchronization of clocks: In SR, each observer is able to synchronize a moving clock to his clock (same value of t in Figure 1 left). But if he does, the two clocks aren't 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 4D vectors $\boldsymbol{\tau}$ and $\boldsymbol{\tau}'$ are never synchronized (different values of d_4 in Figure 1 right). Thus, synchronization of clocks in ER is not as tricky as in SR.

4. Geometric Effects in 4D Euclidean Space

We consider two identical rockets "r" (red rocket) and "b" (blue rocket) and assume: There is an observer R (or B) in the rear end of rocket "r" (or else rocket "b") who uses d_1, d_2, d_3, d_4 (or else d_1', d_2', d_3', d_4') as his coordinates. d_1, d_2, d_3 (or d_1', d_2', d_3') span the 3D space of R (or else B). d_4 (or d_4') relates to the proper time of R (or else B). The rockets started at the same point P and move relative to each other at the constant 3D speed v_{3D}. All 3D motion is in d_1 (or else d_1'). The ES diagrams (Figure 2 top) must fulfill my two postulates and the requirement that both rockets started at the same point P. We achieve this only by rotating the two reference frames with respect to each other. The projection to the 3D space of R (or else B) is shown in Figure 2 bottom. For a better visualization, the rockets are drawn in 2D although their width is in the axes d_2, d_3 and d_2', d_3'.

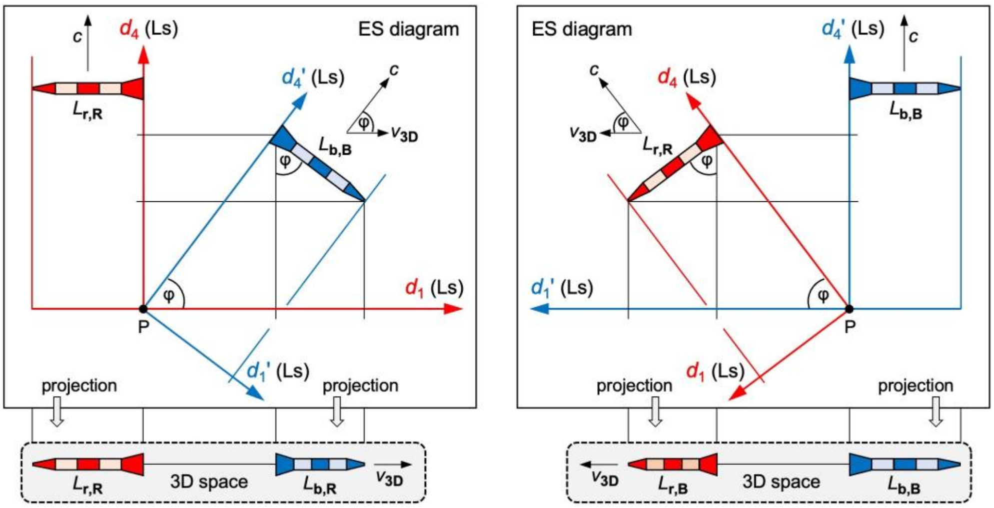

Figure 2. ES diagrams and 3D projections for two rockets "r" (red) and "b" (blue). All axes are in Ls (light seconds). **Top left and right:** In ES, both rockets are moving at the speed c, but in different directions. **Bottom left:** Projection to the 3D space of observer R. Rocket "b" recedes from "r" at the 3D speed v_{3D}. Rocket "b" contracts to $L_{b,R}$. **Bottom right:** Projection to the 3D space of observer B. Rocket "r" recedes from "b" at the 3D speed v_{3D}. Rocket "r" contracts to $L_{r,B}$.

We now confirm: (1) The reference frames of R and B are rotated with respect to each other causing length contraction. (2) The time of R and the time of B flow in different 4D directions causing time dilation. Let $L_{i,R}$ (or $L_{i,B}$) be the length of rocket i as measured by R (or else B). In a first step, we project the blue rocket in Figure 2 top left to the axis d_1.

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

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

where $\gamma = (1 - v_{\mathrm{3D}}^2/c^2)^{-0.5}$ is the same Lorentz factor as in SR. Rocket "b" appears contracted to R by the factor γ^{-1}. But which distances will R observe in his axis d_4? For the answer, we mentally continue the rotation of rocket "b" in Figure 2 top left until it is pointing vertically down ($\varphi = 0°$) and serves as R's ruler in the axis d_4. In the projection to the 3D space of R, this ruler contracts to zero: The axis d_4 disappears for R.

In a second step, we project the blue rocket in Figure 2 top left to the axis d_4.

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

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

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 in an observer's reality because the factor γ is recovered in the projections. This comes as no surprise because the Lorentz group is generated by 4D rotations [17].

To understand how an acceleration in 3D space manifests itself in ES, we now assume that clock "b" accelerates in the axis d_1 of clock "r" towards Earth (Figure 3). We also assume that "r" and Earth are moving in the axis d_4 of "r" at 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.

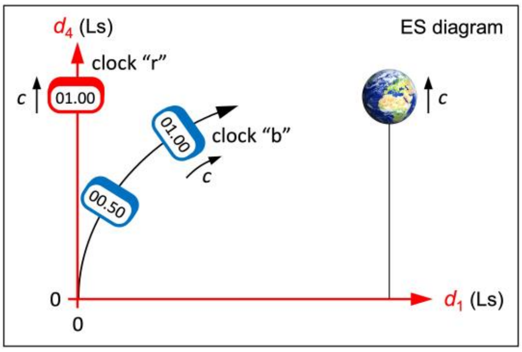

Figure 3. ES diagram for two clocks "r" (red) and "b" (blue). Clock "r" and Earth are moving in the axis d_4 of "r" at the speed c. Clock "b" accelerates in the axis d_1 of "r" towards Earth.

Gravitational waves [18] support the idea of GR that gravitation would be a feature of spacetime. However, particle physics is still considering gravitation a force, which has not yet been unified with the other forces of physics. I claim that curved geodesics in ES replace curved spacetime in GR. To support my claim, I now calculate gravitational time dilation in ES. Let "r" and "b" be two identical clocks far away from Earth. Initially, they move next to each other in the same axis d_4. At some time, "b" is sent in free fall towards Earth in the axis d_1 of "r". The kinetic energy of "b" with the mass m is

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

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

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

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With $u_{4,\mathrm{b}} = \mathrm{d}d_{4,\mathrm{b}}/\mathrm{d}t$ ("b" moves in the axis d_4 at the speed $u_{4,\mathrm{b}}$) and $c = \mathrm{d}d_{4,\mathrm{r}}/\mathrm{d}t$ ("r" moves in the axis d_4 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 in an observer's reality because the factor γ_{gr} is recovered in the projection. Thus, GPS satellites do their job in ER as well as in GR! If clock "b" returns to clock "r", the time displayed by "b" will be behind the time displayed by "r". In ER, this dilation is due to projecting curved geodesics. In GR, it is due to a curved spacetime. Here is a short summary of how time dilation manifests itself in SR, GR, and ER: In SR and ER, a moving clock is slow with respect to an observer. In GR and ER, a clock in a gravitational field is slow with respect to an observer. In SR/GR, an observed clock is slow in its flow of time. In ER, an observed clock is slow in the observer's flow of time.

Three instructive examples (Figure 4) demonstrate how to project from ES to 3D space. Problem 1: A rocket moves along a guide wire. In ES, rocket and wire move at the speed c. We assume that the wire moves in its axis d_4. As the rocket moves along the wire, its speed in d_4 must be slower than c. Wouldn't the wire eventually be outside the rocket? Problem 2: A mirror passes a rocket. An observer in the rocket's tip sends a light pulse to the mirror and tries to detect the reflection. In ES, all objects move at the speed c, but in different directions. We assume that the observer moves in his axis d_4. How can he ever detect the reflection? Problem 3: Earth revolves around the sun. We assume that the sun moves in its axis d_4. As Earth covers distance in d_1, d_2, d_4, its speed in d_4 must be slower than c. Wouldn't the sun escape from the orbital plane of Earth?

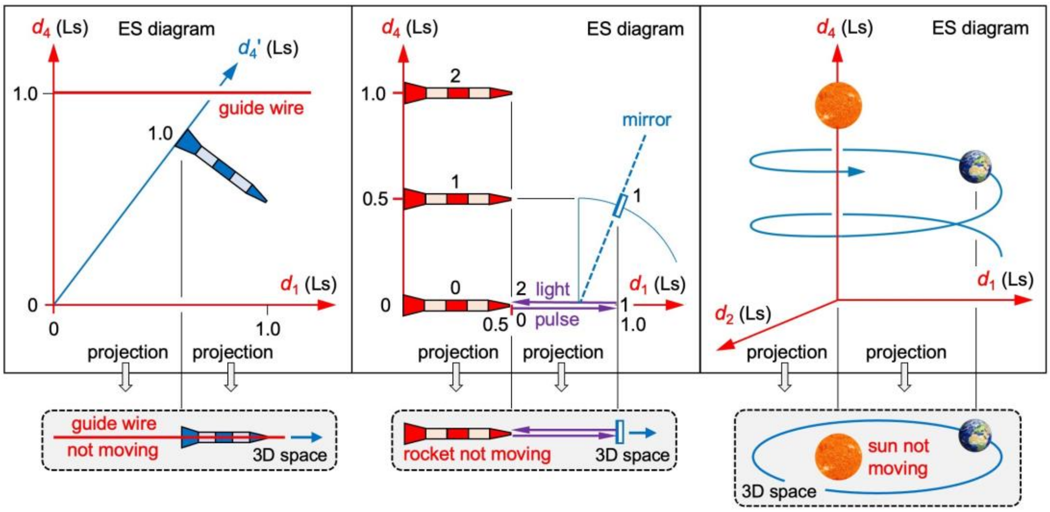

Figure 4. Graphical solutions to three geometric paradoxes. **Left:** A rocket moves along a guide wire. In 3D space, the guide wire remains within the rocket. **Center:** An observer in a rocket's tip tries to detect the reflection of a light pulse. Between two snapshots (0–1 or 1–2), rocket, mirror, and light pulse move 0.5 Ls in ES. In 3D space, the light pulse is reflected back to the observer. **Right:** Earth revolves around the sun. In 3D space, the sun remains in the orbital plane of Earth.

The questions in the last paragraph seem to imply that there are geometric paradoxes in ER, but there aren't. The fallacy in all problems lies in the assumption that there would be four observable (spatial) dimensions. Just three distances are observable! All problems are solved by projecting ES to 3D space (Figure 4 bottom). These projections tell us what an observer's reality is like because "suppressing the axis d_4" is equivalent to "length contraction makes d_4 disappear". The suppressed axis d_4 is experienced as time. We easily verify in an observer's 3D space: The guide wire remains within the rocket; the light pulse is reflected back to the observer; the sun remains in the orbital plane of Earth.

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5. Solving 15 Fundamental Mysteries of Physics

I recall: (1) Each observer's reality is created by projecting ES. (2) In SR/GR, the four axes of such a reality are reassembled to a non-Euclidean spacetime. Because information is lost in each projection, the performance of SR/GR is limited. In Sects. 5.1 trough 5.15, ER solves 15 mysteries of physics and declares five concepts of physics obsolete.

5.1. Solving the Mystery of Time

Cosmic time is the total distance covered in ES divided by c. Proper time is what any clock measures (distance d_4 divided by c). There is no definition of coordinate time other than "what I read on my clock" (with special emphasis on "I" and "my").

5.2. Solving the Mystery of Time's Arrow

The arrow of time is a synonym for "time moving only forward". It emerges from the fact that the distance covered in ES is steadily increasing.

5.3. Solving the Mystery of the Factor c^2 in mc^2

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

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

where $E_{\text{kin,3D}}$ is its kinetic energy in 3D space and mc^2 is its energy at rest. SR does not tell us why there is a factor c^2 in the energy of objects that in SR never move at the speed c. ER provides this missing clue: $E_{\text{kin,3D}}$ is an object's kinetic energy in the axes d_1, d_2, d_3 of the observer, mc^2 is its kinetic energy in his axis d_4, and γmc^2 is the sum of both energies. Eq. (17) tells us: All energy is moving through ES at the speed c. There is also

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

where p is the total momentum of an object and p_{3D} is its momentum in 3D space. After dividing Eq. (18) by c^2, we recognize the vector addition of an object's momentum p_{3D} in the axes d_1, d_2, d_3 of the observer and its momentum mc in his axis d_4.

5.4. Solving the Mystery of Length Contraction and Time Dilation

ER discloses that length contraction and time dilation stem from projecting ES to an observer's reality. In SR, length contraction and time dilation can be derived from the Lorentz transformation, but their physical cause remains in the dark.

5.5. Solving the Mystery of Gravitational Time Dilation

ER discloses that gravitational time dilation stems from projecting curved geodesics in ES to the axis d_4 of an observer. If an object accelerates in his proper space, it automatically decelerates in his proper time. In GR, gravitational time dilation is due to a curved spacetime. However, GR and ER do not compete against each other. GR describes an observer's reality. ER describes the master reality. Of course, more studies will be necessary that address gravitation and gravitational effects in ER.

5.6. Solving the Mystery of the Cosmic Microwave Background

In this section, I outline an ER-based model of cosmology. There is no need to create ES. Space exists just like numbers. For some reason, there was a Big Bang. In the GR-based Lambda-CDM model, the Big Bang occurred "everywhere" because space inflated from a singularity. In the ER-based model, we can localize the Big Bang: It injected a huge amount of energy into a non-inflating and non-expanding ES all at once at what I call "origin O", the only natural reference point. *The Big Bang was a singularity in provided energy.* Initially, all energy receded radially from O at the speed c. Thus, the Big Bang also provided radial momentum. Today, all energy is confined to a 4D

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hypersphere with the radius r. A lot of energy is confined to its 3D hypersurface, which is expanding at the speed c. Interactions (such as the isotropic emission of photons or transversal acceleration) caused some energy to depart from its radial motion while keeping the speed c.

Shortly after the Big Bang, energy was highly concentrated in ES. In the projection to any reality, a very hot and dense plasma was created. While this plasma was expanding, it cooled down. During plasma recombination, radiation was emitted, which we observe as cosmic microwave background (CMB) today [19]. At temperatures of roughly 3,000 K, hydrogen atoms formed. The universe became more and more transparent for the CMB. In the Lambda-CDM model, this stage was reached 380,000 years "after" the Big Bang. In the ER-based model, these are 380,000 light years "away from" the Big Bang. If there was no cosmic inflation (see Sect. 5.9), the value "380,000" needs to be recalculated.

In Figure 5, the axes d_1 and d_4 belong to observers on Earth (Earth is moving in d_4). A lot of energy moves radially: It keeps the radial momentum provided by the Big Bang. The CMB in Figure 5 left moves transversally to d_4. It cannot move in d_4 because it already moves in d_1 at the speed c. Now we interpret three observations: (1) The CMB is nearly isotropic because it was created equally in the 3D space d_1, d_2, d_3 of an observer's reality. (2) The temperature of the CMB is very low because of a very high recession speed v'_{3D} (see Sect. 5.10) of all involved plasma particles. (3) We still observe the CMB today because it started moving at a very low speed $c' \ll c$ in a very dense medium.

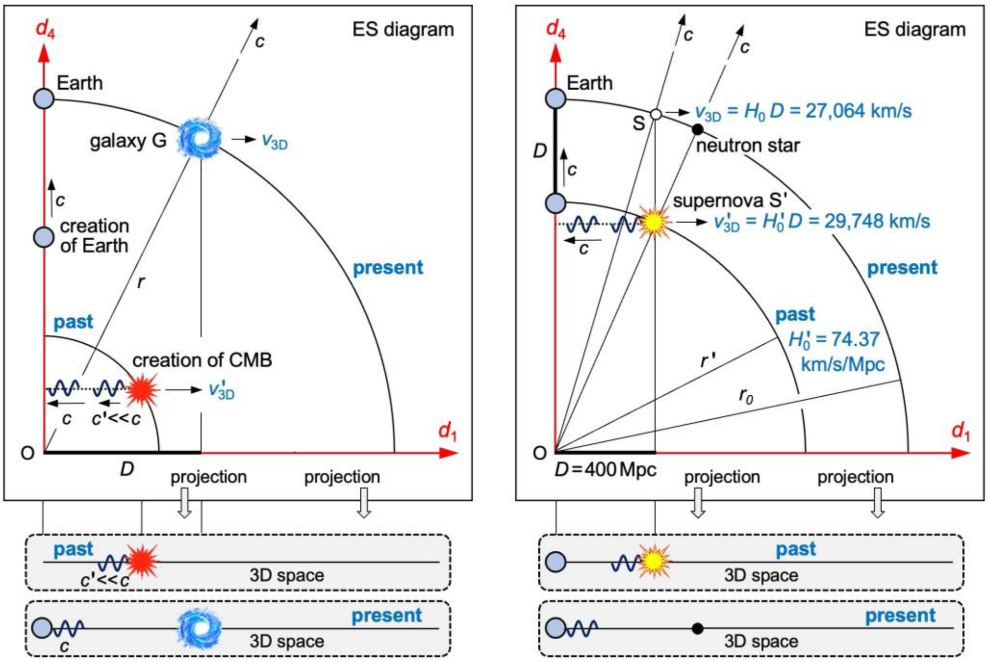

Figure 5. ES diagrams and 3D projections for solving the mysteries 5.6, 5.7, and 5.10. The displayed circular arcs are part of a 3D hypersurface, which is expanding in ES at the speed c. **Left:** The CMB was created in the past and started moving at a speed $c' \ll c$. The galaxy G is receding from Earth today at the speed v_{3D}. **Right:** A supernova S′ occurred in the past when the radius r' of the hypersurface was smaller than today's radius r_0. It occurred at the distance of $D = 400$ Mpc from Earth. If a supernova S occurs today at the same distance D, it recedes slower than S′.

5.7. Solving the Mystery of the Hubble–Lemaître law

The speed v_{3D} at which a galaxy G recedes from Earth in 3D space today (Figure 5 left) relates to their 3D distance D as c relates to today's radius r of the 4D hypersphere.

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

where $H_t = c/r = 1/t$ is the Hubble parameter and t is the cosmic time elapsed since the Big Bang. Eq. (19) is the Hubble–Lemaître law [20,21]: The farther a galaxy, the faster it is receding from Earth. Cosmologists are already aware that H_t is a parameter rather than a constant. They are not yet aware of the 4D Euclidean geometry.

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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: a flat 3D space and time.

5.9. Solving the Mystery of Cosmic Inflation

It is assumed that a cosmic inflation of space in the early universe [22,23] caused the isotropic CMB, the flatness of the universe, and large-scale structures (inflated from quantum fluctuations). I just demonstrated that ER explains the first two observations. ER also explains the third observation if we assume that the impacts of quantum fluctuations have been expanding in ES at the speed c. ***In ER, cosmic inflation is an obsolete concept.***

5.10. Solving the Mystery of the Hubble Tension

There are several methods for calculating the Hubble constant $H_0 = c/r_0$, where r_0 is today's radius of the 4D hypersphere. Up next, I explain why the calculated values of H_0 do not match (known as the "Hubble tension"). I compare measurements of the CMB using the *Planck space telescope* with calibrated distance ladder techniques using the *Hubble space telescope.* According to team A [24], there is $H_0 = 67.66 \pm 0.42$ km/s/Mpc. According to team B [25], 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. I will show that misinterpreting the redshift data causes a systematic error in team B's calculation of H_0. We assume that the value of team A is correct. We now simulate a supernova S′ at the distance of $D =$ 400 Mpc. If this supernova occurred today (S in Figure 5 right), we would calculate from Eq. (19)

$$v_{3D} \;=\; H_0\, D \;=\; 27{,}064 \text{ km/s} \;, \tag{20}$$

$$z \;=\; \Delta\lambda/\lambda_{\text{emit}} \;\approx\; v_{3D}/c \;=\; 0.0903 \;, \tag{21}$$

where the redshift parameter z tells us how each emitted wavelength λ_{emit} of the supernova's light is either *passively stretched* by an expanding space (team B), or how each λ_{emit} is redshifted by the Doppler effect of *actively receding* objects (ER-based model). In Figure 5 right, there is an arc called "past" when the supernova S′ occurred and an arc called "present" when its light arrives on Earth. Team B receives data from a time $t' = 1/H_{t'}$ when there was $r' < r_0$ and $H_{t'} > H_0$. Because of my first postulate, Earth moved the same distance D, but in the axis d_4, when the light of S′ arrives. Thus, there is

$$1/H_{t'} \;=\; r'/c \;=\; (r_0 - D)/c \;=\; 1/H_0 \;-\; D/c \;, \tag{22}$$

$$H_{t'} \;=\; 74.37 \text{ km/s/Mpc} \;. \tag{23}$$

Since team B is not aware of Eq. (22), it concludes that 74.37 km/s/Mpc would be the value of H_0. In truth, team B ends up with a value $H_{t'}$ of the past. For a short distance of $D = 400$ kpc, Eq. (22) tells us that $H_{t'}$ deviates from H_0 by only 0.009 percent. But when plotting v'_{3D} versus D for long distances (50 Mpc, 100 Mpc, ..., 450 Mpc), the slope $H_{t'}$ is 8 to 9 percent higher than H_0, which solves the Hubble tension. I ask team B to recalculate H_0 after converting all v'_{3D} to today's value v_{3D}. Eq. (22) tells us how to do so:

$$H_{t'} \;=\; H_0\, c \,/\, (c \;-\; H_0\, D) \;=\; H_0 \,/\, (1 \;-\; v_{3D}/c) \;, \tag{24}$$

$$v_{3D} \;=\; v'_{3D} \,/\, (1 \;+\; v'_{3D}/c) \;. \tag{25}$$

Of course, team B is well aware of the fact that the supernova's light was emitted in the past. But in the Lambda-CDM model, all that counts is the timespan during which the light is moving to Earth. Along the way, each wavelength λ_{emit} is continuously stretched by expanding space. Thus, the redshift parameter z is increasing during the journey to Earth. That moment when the supernova occurred is irrelevant. In the ER-based model, that moment is relevant, but the timespan is irrelevant. Each λ_{emit} is initially redshifted at the cosmic time t' by the Doppler effect. During the journey to

Earth, the redshift parameter z' remains constant. It is tied up in a "package" when the supernova occurs and sent to Earth, where it is measured. A 3D hypersurface (defined by its contained energy!) is expanding in 4D space. ***In ER, expansion of space is an obsolete concept.***

5.11. Solving the Mystery of Dark Energy

Team B can fix the systematic error in its calculation of H_0 within the Lambda-CDM model by converting all v'_{3D} to v_{3D} according to Eq. (25). Now I reveal another systematic error that is inherent in the Lambda-CDM model itself. It has to do with assuming an accelerating expansion of space, and it can only be fixed by replacing that model with the ER-based model of cosmology (unless we postulate a dark energy). Today's cosmologists [26,27] favor an accelerating expansion of space because the calculated recession speeds deviate from the values predicted by Eq. (19). The deviations increase with distance, and an accelerating expansion of space would stretch each λ_{emit} even more.

The ER-based model gives a simpler explanation for the deviations from the Hubble–Lemaître law: $H_{t'} = 1/t'$ from any past is higher than H_0. The older the redshift data, the more does $H_{t'}$ deviate from H_0, and the more does v'_{3D} deviate from v_{3D}. If a supernova S (small white circle in Figure 5 right) occurred today at the same distance of 400 Mpc as S′, the supernova S would recede slower (27,064 km/s) than S′ (29,748 km/s) just because $H_{t'}$ deviates from H_0. As long as we are not familiar with the 4D Euclidean geometry, higher redshifts are attributed to an accelerating expansion of space. Now that we know the 4D geometry, we can attribute higher redshifts to data from deeper pasts.

In the ER-based model, all redshifts stem from the Doppler effect of receding galaxies. Because the Lorentz factor is recovered in the projections from ES, the equations of SR remain valid in an observer's reality. Thus, there is

$$\frac{v_{3D}}{c} = \frac{(1+z)^2 - 1}{(1+z)^2 + 1} , \tag{26}$$

where z is the observed redshift. While the supernova's light moved D in the axis d_1, Earth moved the same D in the axis d_4 (Figure 5 right). Let r' be the radius when the light was created. From Eq. (19) and $r' = r_0 - D$, we calculate v'_{3D} at the time t'.

$$v'_{3D} = v_{3D}\, r_0/r' = v_{3D} \,/\, (1 - D/r_0) . \tag{27}$$

Figure 6 shows the distance modulus μ of 16 low-redshift and 24 high-redshift supernovae versus v'_{3D}/c. Low-redshift data were published by Hamuy *et al* [28], high-redshift data by Perlmutter *et al* [26]. I considered those supernovae that had been studied by both [26] and [29]. For all 40 supernovae, I calculated v_{3D} from Eq. (26). Then I used Eq. (27), $D = 10^{0.2\mu+1}$, and $r_0 = 14.25\ \text{Gpc}$ to calculate v'_{3D}.

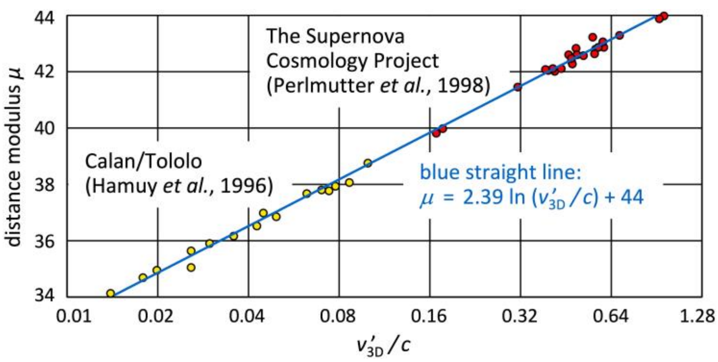

Figure 6. Hubble diagram for 40 Type Ia supernovae. The horizontal axis displays adjusted speeds. All data including their uncertainties are listed in the Appendix A.

Linear regression yields the blue straight line in Figure 6. The equation is given by

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$$v'_{3D} = H_0^* D \ , \tag{28}$$

where H_0^* is a true constant. The offset "44" in Figure 6 relates to $H_0^* \approx 48$ km/s/Mpc (see Appendix B). H_0^* is lower than H_0 in the Lambda-CDM model, but it is not the task of ER to recover a value that stems from a different spacetime. Only in ER do all 40 supernovae (including the high redshifts) fit very well to a straight line. Eq. (28) is the correct Hubble–Lemaître law. Space is not expanding, but energy is receding. The term "dark energy" [30] was coined to explain an accelerating expansion of space. There is no expansion of space. ***In ER, dark energy is an obsolete concept.*** It has never been observed anyway.

Any expansion of space (uniform as well as accelerating) is only virtual. There is no accelerating expansion of the Universe 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" [31]. This praise comes with two misconceptions: (1) In the Lambda-CDM model, "Universe" also implies space, but space is *not expanding* at all. (2) There is receding energy, but it is moving *uniformly* in ES at the speed c. In each observer's reality, there only seems to be an accelerating expansion of space.

Radial momentum provided by the Big Bang drives all galaxies away from the origin O. They are driven by themselves rather than by dark energy. If the 3D hypersurface has always been expanding at the speed c, the time elapsed since the Big Bang is $1/H_0^*$, which is 20.4 billion years rather than 13.8 billion years [32]. The new estimate would explain the existence of stars as old as 14.5 billion years [33]. Table 1 compares two models of cosmology. Be aware that "Universe" (capitalized) in the Lambda-CDM model is not the same as "universe" in the ER-based model. In the next two sections, I will demonstrate that ER is compatible with QM. Since "quantum gravity" is meant to make GR compatible with QM, I conclude: ***In ER, quantum gravity is an obsolete concept.***

Table 1. Comparing the Lambda-CDM model with the ER-based model of cosmology.

Lambda-CDM model based on GR	Model of cosmology based on ER
Big Bang was the beginning of the Universe.	Big Bang was the injection of energy into ES.
Big Bang occurred "everywhere".	Big Bang can be localized at an origin O of ES.
Big Bang occurred about 13.8 billion years ago.	Big Bang occurred about 20.4 billion years ago.
There are two competing values of H_0.	H_0^* is approximately 48 km/s/Mpc.
The Universe: all space, all time, and all energy.	The universe: proper space of an observer.
Space is inflating and expanding.	Galaxies are receding radially in ES.
Space is driven by dark energy.	Galaxies are driven by radial momentum.
Spacetime is curved.	Trajectories of objects are curved in ES.
Time is what I read on my clock.	Time is distance covered in ES divided by c.
GR is not compatible with quantum mechanics.	ER is compatible with quantum mechanics.

5.12. Solving the Mystery of the Wave–Particle Duality

The wave–particle duality was first discussed by Niels Bohr and Werner Heisenberg [34] and has bothered physicists ever since. Electromagnetic waves are oscillations of an electromagnetic field, which propagate through 3D space at the speed c. In some experiments, objects behave like waves. In other experiments, the same objects behave like particles. Up next, I explain how the very same object (here: an electromagnetic wave packet) can be deemed both wave and particle. From an observer's perspective, it is a wave. From its own perspective, it is a particle. The following arguments hold for gravitational waves, too, if the electromagnetic field is replaced with a gravitational field.

To understand the duality, we use a generalized concept of energy: All energy in ES is made up of quanta that may appear as wave packets and particles for different observers. In Figure 7, such an energy quantum "wp" (wave packet) is illustrated. If I observe "wp" (external view, coordinate spacetime), I deem it wave: It propagates in my axis x_1 at the speed c, and it oscillates in my axes x_2 and x_3 (electromagnetic field). Propagating and oscillating occur in coordinate time t. However, "wp" has features of a particle, too: From its own perspective (internal view or "in-flight view", not

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available in SR/GR), the axis of its 4D motion disappears because of length contraction at the speed c. Thus, "wp" deems itself particle at rest. The four dimensions of space enable this internal view.

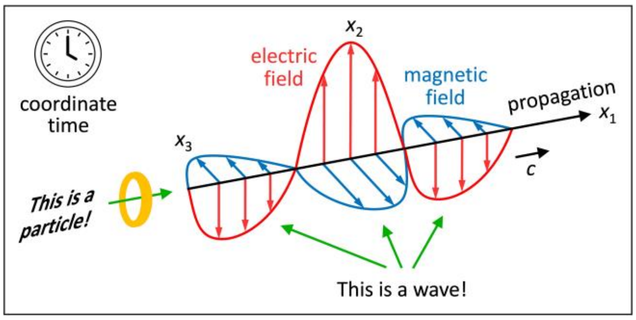

Figure 7. Artwork illustrating how the very same object can be deemed both wave and particle. If I observe a wave packet (external view), it comes in four orthogonal dimensions: propagation, electric field, magnetic field, and coordinate time. I deem it wave. From its own perspective (internal view, not available in SR/GR), the wave packet deems itself particle at rest.

Only the SO(4) symmetry of ES tells us that wave and particle are subjective concepts: What I deem wave packet, deems itself particle at rest. Albert Einstein demonstrated that energy is equivalent to mass [35]. This very equivalence shows itself in the wave–particle duality: Because each wave packet is moving through ES at the speed c, its 4D motion is suppressed for itself. From its own perspective (in its reality), all of its energy "condenses" to what we call "mass" in a particle at rest.

In a double-slit experiment, coherent energy quanta pass through a double-slit and produce some interference pattern on a screen. An observer deems them waves as long as he does not track through which slit each energy quantum is passing. Thus, he is a typical external observer. The photoelectric effect is quite different. Of course, one can externally witness how one photon releases one electron from a metal surface. But the physical effect ("Do I have enough energy to release one electron?") is all up to the photon's view. Only if the photon's energy exceeds the binding energy of an electron is this electron released. Thus, we must interpret the photoelectric effect from the internal view of the photon. Here its view is crucial! The photon behaves like a particle.

The wave–particle duality is also observed in matter, such as electrons [36]. Electrons are energy quanta, too. From the internal view (if I track a single electron), this electron is a particle: Which slit will it pass through? From the external view (if I observe an electron without tracking it), this electron behaves like a wave. Because I automatically track slow objects (slow for me), I deem all macroscopic objects matter rather than waves. This argument justifies drawing solid rockets and celestial bodies in my ES diagrams.

5.13. Solving the Mystery of Non-Locality

The term "entanglement" [37] was coined by Erwin Schrödinger in his comment on the Einstein–Podolsky–Rosen paradox [38]. These three physicists argued that QM would not provide a complete description of reality. Schrödinger's word creation did not solve the paradox, but it demonstrates our difficulties in comprehending QM. John Bell proved that QM is not compatible with local hidden-variable theories [39]. Several experiments have confirmed that entanglement violates the concept of locality [40–42]. Ever since has entanglement been considered a non-local effect.

Now I show how to untangle entanglement *without the concept of non-locality*. All we have to do is discuss it in ES: The fourth dimension of space makes non-locality obsolete. Figure 8 displays two wave packets that were created at once at a point P and are now moving away from each other in opposite directions $\pm d'_4$ at the speed c. These wave packets are entangled. If they are observed by an observer moving in a direction other than $\pm d'_4$ (external view), they appear as two objects. The observer cannot understand how the two wave packets communicate with each other in no time.

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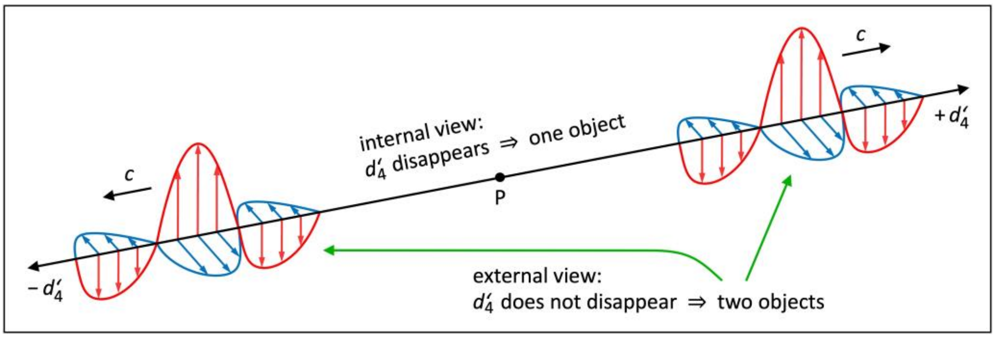

Figure 8. Entanglement in ES. For each displayed wave packet, the axis $\pm d_4'$ disappears because of length contraction. It deems its twin and itself one object (internal view). For an observer moving in a direction other than $\pm d_4'$, the wave packets appear as two objects (external view).

For each wave packet in Figure 8 (internal view), the axis $\pm d_4'$ disappears because of length contraction at the speed c. In their common (!) proper space spanned by d_1', d_2', d_3', either one deems itself at the very same position as its twin. From either perspective, they are one object, which has never been separated. This is how they communicate with each other in no time. There is no "spooky action at a distance". The twins stay together in their proper space even if their proper time flows in opposite directions. Entanglement occurs because an observer's proper space *may be different* from an observed object's proper space. This is possible only if there are four dimensions of space. ER also explains entanglement of electrons or atoms. They move at a speed $v_{3D} < c$ in my proper space, but in their axis $\pm d_4'$ they 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.***

5.14. Solving the Mystery of Spontaneous Effects

In *spontaneous emission*, a photon is emitted by an excited atom. Prior to the emission, the photon's energy was moving with the atom. After the emission, this energy is moving by itself. Today's physics cannot explain how this energy is boosted to the speed c in no time. In ES, both atom and photon are moving at the speed c. So, there is no need to boost any energy to the speed c. All it takes is energy from ES whose 4D motion "swings completely" (rotates by an angle of $90°$) into an observer's 3D space—and this energy speeds off at once. In *absorption*, a photon is spontaneously absorbed by an atom. Today's physics cannot explain how the photon's energy is slowed down to the atom's speed in no time. In ES, both photon and atom are moving at the speed c. So, there is no need to slow down any energy. Similar arguments apply to pair production and to annihilation. Spontaneous effects are another clue that energy is always moving through ES at the speed c.

5.15. Solving the Mystery of the Baryon Asymmetry

According to the Lambda-CDM model, almost all matter in the Universe was created shortly after the Big Bang. Only then was the temperature high enough to enable the pair production of baryons and antibaryons. But the density was also very high so that baryons and antibaryons should have annihilated each other again. Since we do observe a lot more baryons than antibaryons today (known as the "baryon asymmetry"), it is assumed that an excess of baryons must have been produced in the early Universe [43]. However, such an asymmetry in pair production has never been observed.

ER solves the baryon asymmetry: Because each energy quantum deems itself particle, there were particles in ES immediately after the Big Bang. *There are much less antiparticles than particles today because antiparticles are created in pair production only.* One may ask: Why do energy quanta deem themselves particles rather than antiparticles? The answer is that antiparticles are not the opposite of particles. An antiparticle is a particle, too, but with the opposite electric charge. Antiparticles seem to flow backward in time because proper time flows in opposite directions for any two quanta created

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in pair production. As they move in opposite directions at the speed c, they are automatically entangled.

6. Conclusions

ER solves mysteries, which SR/GR either have not solved in 100+ years or which have been solved, but only with concepts that are redundant in ER: cosmic inflation, expansion of space, dark energy, quantum gravity, and non-locality. All these concepts are needed in today's physics to make cosmology and QM work. On the other hand, there are waves (electromagnetic waves, gravitational waves) in today's physics, but not in ES because of its SO(4) symmetry. There is an observer's reality described by SR/GR (with waves) and the master reality ES described by ER (without waves). In the past century, physicists have focused on SR/GR. I showed that there is a lot more physics beyond that.

SR/GR have been confirmed many times over. Thus, they are considered two of the greatest achievements of physics. I demonstrated that their performance is limited, and I suspect that this limitation causes today's stagnation in physics. Physicists feel comfortable with SR/GR, but if we think of an observer's reality as an oversized stage, ER tells us: *The keys to cosmology and QM are beyond the curtain of this stage.* Only in natural spacetime does nature disclose her secrets. The deflection of starlight is an impressive confirmation of GR. We must not believe that an impressive confirmation of ER would still be missing. 15 solved mysteries speak for themselves. While SR/GR are mathematically correct, their respective concepts of spacetime are construed and thus not natural.

It was a wise decision to award Albert Einstein the Nobel Prize for his theory of the photoelectric effect [44] rather than for SR/GR. ER penetrates to a deeper level. Einstein, one of the most brilliant physicists ever, did not realize that the fundamental metric chosen by nature is Euclidean. He sacrificed absolute space and time. I sacrifice the absoluteness of waves and particles, but I do restore absolute time (cosmic time). For the first time, mankind understands the nature of time: Time is distance covered in ES divided by the speed c. The human brain is able to imagine that we are moving through 4D space at the speed of light. *With that said, conflicts of mankind become all so small.*

Final remarks: (1) I addressed gravitation only briefly, but I ask you once more to be patient and fair. We should not reject ER just because gravitational effects are not yet fully understood. It is promising that ER predicts the same gravitational lensing and the same perihelion precession of elliptical orbits as GR [11]. (2) The beauty of ER is its symmetry. But to cherish ER we must give ourselves a push by accepting that an observer's reality is a projection. We must not ask in physics: Why is it a projection? Nor must we ask: Why is it a probability function? (3) It looks like Plato was right with his *Allegory of the Cave* [45]: Mankind experiences a projection that is blurred because of QM. It is not by chance that the author of this paper is an experimental physicist. The construed concepts of spacetime in SR/GR are not suspicious to theorists. This paper lays the groundwork for ER. Everyone is welcome to join in! May ER now get the broad acceptance that it deserves.

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Data Availability Statement: All data displayed in Figure 6 are listed in the Appendix A.

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Comments: It takes open-minded and courageous reviewers to evaluate a theory that comes with a paradigm shift. Reviewers who stick to traditional concepts are paralyzing the progress in physics. Unfortunately, several friends and colleagues refused their support because they feared about their good reputation. Here are some anonymized comments of reviewers, which show how troublesome it is to oppose the mainstream: "Unscholarly research." "Fake science." "The math is too simple to be true." The editor-in-chief of a top journal did not even

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look at my manuscript: "Publishing is for experts only!" A well-known preprint repository suspended my submission privileges.

Appendix A

All data displayed in Figure 6 including their uncertainties.
Col. 1: IAU name assigned to the supernova.
Col. 2: Redshift z according to [26].
Col. 3: Uncertainty in z according to [26].
Col. 4: Distance modulus μ according to [29].
Col. 5: Uncertainty in μ according to [29].
Col. 6: Distance D in parsec calculated from $D = 10^{0.2\mu+1}$.
Col. 7: v_{3D}/c calculated from Eq. (26).
Col. 8: v'_{3D}/c calculated from Eq. (27).

SN	z	σ_z	μ	σ_μ	D (pc)	v_{3D}/c	v'_{3D}/c
1990O	0.030	0.002	35.90	0.20	1.514E8	0.0296	0.0299
1990af	0.050	0.002	36.84	0.21	2.333E8	0.0488	0.0496
1992P	0.026	0.002	35.64	0.20	1.343E8	0.0257	0.0259
1992ae	0.075	0.002	37.77	0.19	3.581E8	0.0722	0.0741
1992ag	0.026	0.002	35.06	0.24	1.028E8	0.0257	0.0259
1992al	0.014	0.002	34.12	0.25	6.668E7	0.0139	0.0140
1992aq	0.101	0.002	38.73	0.20	5.572E8	0.0959	0.0998
1992bc	0.020	0.002	34.96	0.22	9.817E7	0.0198	0.0199
1992bg	0.036	0.002	36.17	0.19	1.714E8	0.0354	0.0358
1992bh	0.045	0.002	36.97	0.18	2.477E8	0.0440	0.0448
1992bl	0.043	0.002	36.53	0.19	2.023E8	0.0421	0.0427
1992bo	0.018	0.002	34.70	0.23	8.710E7	0.0178	0.0179
1992bp	0.079	0.002	37.94	0.18	3.873E8	0.0759	0.0780
1992br	0.088	0.002	38.07	0.28	4.111E8	0.0841	0.0866
1992bs	0.063	0.002	37.67	0.19	3.420E8	0.0610	0.0625
1993B	0.071	0.002	37.78	0.19	3.597E8	0.0685	0.0703
1995ar	0.465	0.005	42.81	0.22	3.648E9	0.3643	0.4896
1995as	0.498	0.001	43.21	0.24	4.385E9	0.3835	0.5540
1995aw	0.400	0.030	42.04	0.19	2.559E9	0.3243	0.3953
1995ax	0.615	0.001	42.85	0.23	3.715E9	0.4457	0.6029
1995ay	0.480	0.001	42.37	0.20	2.979E9	0.3731	0.4717
1995ba	0.388	0.001	42.07	0.19	2.594E9	0.3166	0.3871
1996cf	0.570	0.010	42.77	0.19	3.581E9	0.4228	0.5647
1996cg	0.490	0.010	42.58	0.19	3.281E9	0.3789	0.4922
1996ci	0.495	0.001	42.25	0.19	2.818E9	0.3818	0.4759
1996cl	0.828	0.001	43.96	0.46	6.194E9	0.5393	0.9540
1996cm	0.450	0.010	42.58	0.19	3.281E9	0.3554	0.4617
1997F	0.580	0.001	43.04	0.21	4.055E9	0.4280	0.5982
1997H	0.526	0.001	42.56	0.18	3.251E9	0.3992	0.5172
1997I	0.172	0.001	39.79	0.18	9.078E8	0.1574	0.1681
1997N	0.180	0.001	39.98	0.18	9.908E8	0.1640	0.1763
1997P	0.472	0.001	42.46	0.19	3.105E9	0.3684	0.4710
1997Q	0.430	0.010	41.99	0.18	2.500E9	0.3432	0.4162
1997R	0.657	0.001	43.27	0.20	4.508E9	0.4660	0.6816
1997ac	0.320	0.010	41.45	0.18	1.950E9	0.2707	0.3136
1997af	0.579	0.001	42.86	0.19	3.733E9	0.4275	0.5792
1997ai	0.450	0.010	42.10	0.23	2.630E9	0.3554	0.4358
1997aj	0.581	0.001	42.63	0.19	3.357E9	0.4285	0.5606
1997am	0.416	0.001	42.10	0.19	2.630E9	0.3345	0.4102
1997ap	0.830	0.010	43.85	0.19	5.888E9	0.5401	0.9205

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Appendix B

Estimation of H_0^*.

$$\mu = 2.39\ln(v'_{3\mathrm{D}}/c) + 44$$
$$5\log D - 5 = 2.39\ln(v'_{3\mathrm{D}}/c) + 44$$
$$\ln D/\ln 10 = 0.478\ln(v'_{3\mathrm{D}}/c) + 9.8$$
$$\ln D = 1.1\ \ln(v'_{3\mathrm{D}}/c) + 22.6$$
$$D \approx (v'_{3\mathrm{D}}/c) \times 6.31\mathrm{E}9$$
$$v'_{3\mathrm{D}} \approx D \times 0.048\ \mathrm{m/s/pc}$$
$$H_0^* \approx 48\ \mathrm{km/s/Mpc}$$

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