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Can Physics Benefit from a New Concept of Time?

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Abstract: Today's concept of time is based on Einstein's theories of special (SR) and general relativity (GR). Many physicists anticipate that GR has an issue since it is not compatible with quantum mechanics. **Here we show:** SR and GR work well for each observer describing his unique reality, but "Einstein time" (Einstein's concept of time) has an issue. It arranges all events in the universe in a 1D line on my watch, yet neither cosmology nor quantum mechanics care about my watch. In Euclidean relativity (ER), we replace Einstein time (coordinate time of an observer) with Euclidean time (proper time of each object). In Euclidean spacetime (ES), all energy is moving at the speed of light. For each observed object, Euclidean time flows in a 4D direction equal to its direction of motion. The projection of the object's 4D vector "flow of time" to an observer's direction of motion yields its motion in his Einstein time. Because of the projection, Einstein time provides less information than Euclidean time. ER gives us the same Lorentz factor as in SR and the same gravitational time dilation as in GR. Yet ER outperforms SR in explaining time's arrow and mc^2. ER outperforms a GR-based cosmology in solving competing Hubble constants and declaring cosmic inflation, expansion of space, and dark energy redundant. Most important, ER is compatible with quantum mechanics: It solves the wave–particle duality and quantum entanglement while declaring non-locality redundant. **We conclude:** Physics based on Euclidean time penetrates to a deeper level and makes less assumptions.

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Important Remarks

We kindly ask all readers including editors and reviewers to read these preliminary remarks. They help you to avoid those traps that previous reviewers already stepped into. Most readers seem to believe that our theory is just another attempt to identify an issue in Einstein's theory of special relativity (SR) [1]. Since SR has been experimentally confirmed many times over, our theory is considered a waste of time. What they don't see: The issue is in Einstein's concept of time! It affects *all of physics* including SR, general relativity (GR) [2], and quantum mechanics. We do not dispute any predictions made by SR or GR. Quite the opposite is true: The Lorentz factor is recovered in our theory, and we explain why SR and GR work so well despite the issue in Einstein's concept of time.

Yet it is because of this issue in today's concept of time that GR is not compatible with quantum mechanics. We make three changes to the foundations of physics—new concepts of time, distance, and energy—that make relativity compatible with quantum mechanics. Isn't that reason enough to give our theory of Euclidean relativity (ER) a chance? We must ask this question because one editor informed us that some journals do not consider refutations of SR. Sorry, but why is that? Do they fear that their reputation could be damaged? Have SR and GR turned into a dogma that must not be questioned anymore? A theory is scientific only if it is falsifiable [3]. Neither SR nor GR nor ER is ever set in stone!

Our recent submission to a renowned journal was rejected by one peer reviewer who argued: "Modern physics is the discovery that a notion of universal time plays no role in the phenomena we observe." Nonsense! Today's physics works well without an absolute time, **but only if other—more speculative—concepts are added.** This one reviewer didn't consider all the benefits of our theory. If he did, he would have noticed that we get along without cosmic inflation, expansion of space, dark energy, and non-locality. Isn't that reason enough to promote scientific discussion of our theory in a journal?

Six pieces of advice: (1) Imagine that sticking to Einstein's egocentric concept of time could be the same mistake as sticking to the geocentric model. Learn in our paper about all the benefits of replacing Einstein's concept of time. (2) Don't be prejudiced against a theory which claims to solve 15 mysteries at once. It isn't unusual that new concepts give many answers at once. (3) Don't take SR and GR for granted while evaluating ER. Previous reviewers made a severe, systematic error by doing so. ER is different. In ER, everything is moving at the speed of light. (4) Evaluate ER reasonably. The Lorentz factor is recovered in ER. So, this argument doesn't favor SR. Yet ER does solve mysteries that SR and GR haven't solved in 100+ years. (5) Be patient and fair. Don't expect that we address all of physics in one paper. SR and GR have been tested for 100+ years. We must wait for ER to prove itself, too. (6) Let illustrations assist you to conceive of 4D. Geometric derivations are equivalent to equations.

Also consider: (7) It is very unlikely that a new concept of time is mistaken if it solves 15 fundamental mysteries at once. (8) Science should discuss an original stance on fundamental issues rather than dismissing it on a knee-jerk reaction. (9) Today's physics cannot be complete since GR is not compatible with quantum mechanics. (10) If you are an expert in inflation theory, dark energy, or quantum gravity, bear in mind that you are biased. ER doesn't need any of these theories/concepts, and that might be hard to accept.

To sum it all up: Predictions made by SR and GR are correct, but ER penetrates to a deeper level. We do apologize for having published several preprint versions. It was really tricky to figure out why SR and GR make correct predictions despite the issue in Einstein's concept of time. Sect. 2 is about disclosing this issue. Sect. 3 gives us an intuitive approach to Euclidean time. In Sect. 4, we derive the Lorentz factor and gravitational time dilation. In Sect. 5, we solve 15 mysteries and declare four concepts of today's physics redundant. In our Conclusions, Occam's razor knocks out Einstein's concept of time.

1. Introduction

Today's concepts of space and time were coined by Albert Einstein. His theory of SR [1] is based on a flat spacetime with an indefinite distance function. SR is often interpreted in Minkowski spacetime (MS) because Minkowski's geometric interpretation [4] was very successful in explaining relativistic effects. Predicting the lifetime of muons [5] is one example that demonstrates the power of SR. General relativity (GR) [2] is based on a curved spacetime with a pseudo-Riemannian metric. GR is supported, for example, by the deflection of starlight during a solar eclipse [6] and by the high accuracy of GPS. Quantum field theory [7] unifies classical field theory, SR, and quantum mechanics, but not GR.

We call our theory "Euclidean relativity" and build it on these three postulates: (1) In Euclidean spacetime (ES), all energy is moving at the speed of light. (2) The laws of physics have the same form in each observer's "reality" (orthogonal projections of ES to his proper 3D space and to his proper flow of time). (3) All energy is "wavematter" (electromagnetic wave packet and matter in one). Our first postulate is stronger than Einstein's second postulate. The speed of light c is both absolute and universal. Everything is moving through ES at the speed c. Moving through MS at the speed c is a pointless idea: Objects "at rest" in 3D space would move in time at *one second per one second*. Our second postulate matches Einstein's first postulate, except that it isn't limited to inertial frames, but to an observer's reality. Our third postulate makes relativity compatible with quantum mechanics.

We aren't the first physicists to investigate ER: In the early 1990s, Montanus already described ES [8]. He also formulated electrodynamics and gravitational lensing in ES [9]. Almeida compared trajectories in MS with trajectories in ES [10]. Gersten demonstrated that the Lorentz transformation is equivalent to an SO(4) rotation [11]. van Linden studied energy and momentum in ES [12]. Pereira claimed a "hypergeometrical universe", where matter is made from deformed space [13]. Yet none of these models identifies the issue in Einstein's concept of time. And they all run into geometric paradoxes discussed in Sect. 4 because they don't project ES to an observer's reality. Only Machotka added a "boundedness postulate" to avoid paradoxes [14], but it sounds rather contrived. We overcome such paradoxes by limiting our second postulate to an observer's reality.

It is instructive to compare our theory with Newton's physics and Einstein's physics. In Newton's physics, all objects are moving through 3D space as a function of an independent time. The speed of matter is $v_{3D} \ll c$. In Einstein's physics, all objects are moving through 4D spacetime given by 3D space and time, where time is linked to, but different from space (time is measured in seconds). The speed of matter is $v_{3D} < c$. In our theory, all objects are moving through 4D ES given by four symmetric distances (all distances are measured in light seconds), where time is only a subordinate quantity. The 4D speed of everything is $u_{4D} = c$. Newton's physics inspired Kant's philosophy [15]. Our theory will have a huge impact on modern physics and philosophy. Replacing the concept of time is probably the biggest adjustment since the formulation of quantum mechanics.

2. An Issue in Einstein's Concept of Time

Today's concept of time traces back to Albert Einstein. We thus call it "Einstein time" t. § 1 of SR [1] is an instruction of how to synchronize two clocks at the positions P and Q. At "P time" t_P, an observer sends a light pulse from P towards Q. At "Q time" t_Q, it is reflected at Q towards P. At "P time" t_P^*, it is back at P. Both clocks synchronize if

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

In § 3 of SR [1], Einstein derives the Lorentz transformation for two systems moving relative to each other at a constant speed. 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' of that event in a system K′ by

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

$$x_2' = x_2 \tag{2b}$$

$$x_3' = x_3 \tag{2c}$$

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

where the system K′ is moving relative to K in the axis x_1 and at the constant speed v_{3D}. The factor $\gamma = (1 - v_{3D}^2/c^2)^{-0.5}$ is the Lorentz factor.

Equations (1) and (2a-d) are correct for one observer R in K describing his reality. Because of the relativity postulate, we can write down a similar set of equations for one observer B in K′ describing his reality. So, all theories that are consistent with SR (such as electrodynamics) will be valid for either observer. SR works well for each observer describing his reality, but Einstein time has an issue. It arranges all events in the universe in a 1D line on my watch, yet neither cosmology nor quantum mechanics care about my watch. Einstein time is *egocentric:* It considers the watch of an observer ("ego") the center of time, just as the *geocentric* model considers Earth ("geo") the center of the solar system. This analogy (and the pun "ego/geo") should give food for thought to all skeptics.

In order to find an alternative concept of time, we now take a closer look at the effect of time dilation. In § 4 of SR [1], Einstein derives that there is a dilation in Einstein time: The clock of an observer B in K′ is slow with respect to the clock of an observer R in K by the factor γ. Time dilation has been experimentally confirmed. So, any alternative concept must recover it and the same γ. **Now watch out as the next sentences are our entrance to ER:** Most physicists aren't aware that there are two variables in which this time dilation can show up for the same (!) observer R. Einstein and Minkowski assumed that the clock of B is slow with respect to R in t' ("proper time" of B). As we explain next, it can also be slow with respect to R in t ("coordinate time" of R).

Figure 1 top illustrates a Minkowski diagram of two identical rockets—except for their color—with a proper length of 0.5 Ls (light seconds). They started at the origin and move relative to each other in the axis x_1 at a speed of 0.6 c. We choose these very high values to visualize relativistic effects. We show that moment when the red rocket has moved 1 s in t. Observer R is in the rear end of the red rocket r. His/her view is the red frame with the coordinates x_1 and t. Observer B is in the rear end of the blue rocket b. His/her view is the blue frame with the coordinates x'_1 and t'. Only for visualization do we draw our rockets in 2D although their width is in the dimensions x_2, x_3 or x'_2, x'_3 (not displayed in Figure 1). For R, the blue rocket contracts to 0.4 Ls *because of length contraction.* For B, the rear end of the blue rocket has moved only 0.8 s in t' *because of time dilation.*

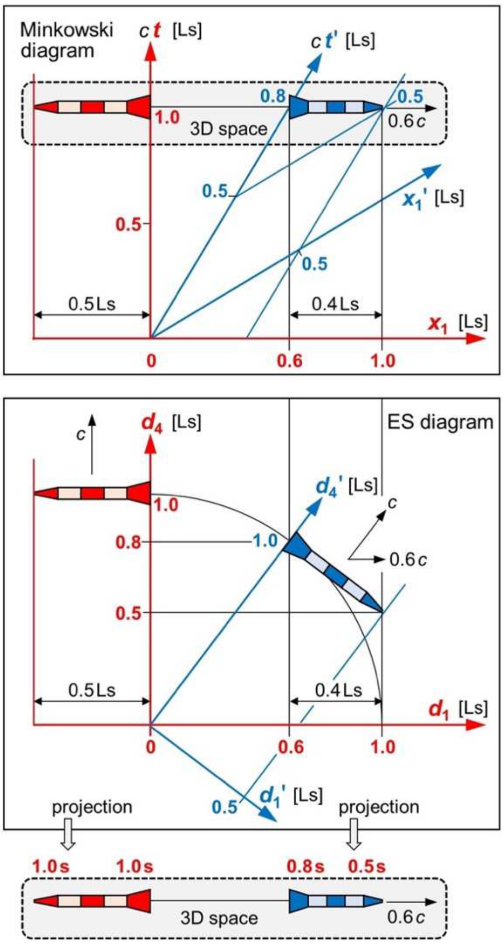

Figure 1. Minkowski diagram, ES diagram, and 3D projection for two identical rockets. **Top:** The Minkowski diagram depicts the reality of just one observer (here of R who synchronizes all clocks inside both rockets). Our diagram doesn't depict the reality of B who would also synchronize these clocks. **Center:** The ES diagram can be projected to either reality. **Bottom:** Projection to the 3D space of R.

It is well known that simultaneity isn't absolute in SR. In Figure 1 top, R synchronized all clocks inside r and b according to § 2 of SR [1]: $t = 1.0$ s. In this diagram, clocks inside b display a different time for B: $t' = 0.8$ s and $t' = 0.5$ s. Clocks that are synchronized for R aren't synchronized for B. Yet we must assume that B would also synchronize all clocks inside r and b. To depict the reality of B, we must draw a second Minkowski diagram (not shown here) where clocks inside r aren't synchronized for R. Since we need two diagrams, we can't take the measurements of R and B seriously *at once.* In SR, there is no "at once for both". Each observer claims just for himself that all clocks are synchronized.

In experimental physics, we are used to take measurements of all observers seriously at once. We can do so if we claim: *Each observer measures clocks inside his own rocket as synchronous, while he measures all moving clocks as asynchronous.* We get to this "Euclidean time" by replacing the asymmetric axes x_1 and t with symmetric distances d_1 and d_4, and by rotating rocket b thereafter. We then end up with an ES diagram (Figure 1 center) in which the two values "0.8" and "0.5" show up in d_4 (which belongs to R).

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In MS, t is the coordinate time of R, and t' is the proper time of B. In ES, R uses the same variable d_4 for measuring the time of R and for measuring the time of B. **In either case (MS and ES), the clock of B is slow with respect to R.** In MS, it is slow with respect to R in t' (which belongs to B). In ES, it is slow with respect to R in d_4 related to t (which belongs to R). Common sense tells us that two identical clocks run the same whether or not they move relative to each other. This is true in ES: Only by observing a moving clock (by projecting d_4' to d_4) does this clock become slow with respect to R.

3. Introducing Euclidean Time and Euclidean Spacetime

MS comes with an indefinite (not positive semidefinite) distance function, which is usually written as

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

where τ is the proper time of an object and t is the coordinate time of an observer. We can rearrange the terms in Equation (3a), so that we end up with a Euclidean metric

$$(c\,\mathrm{d}t)^2 \;=\; \mathrm{d}d_1^2 + \mathrm{d}d_2^2 + \mathrm{d}d_3^2 + \mathrm{d}d_4^2 \tag{3b}$$

where $d_i = x_i$ for $i = 1,2,3$ and $d_4 = c\tau$. The roles of Einstein time t (coordinate time of an observer) and Euclidean time τ (proper time of each object) have switched: All invariants are now based on t, whereas the fourth dimension in all vectors is now based on τ. The switch affects all time-dependent equations of physics and must not be confused with the "Wick rotation" [16], which replaces t by it, but keeps τ as the invariant.

Euclidean time isn't egocentric (centered in the observer), but universal (centered in each object of the universe). Our word "object" includes observers, while "observed object" excludes observers. Because of the symmetry in Equation (3b), we are free to label the four axes. We assume: Each object moves only in its axis d_4. According to our first postulate, it does so at the speed c. *Euclidean time is distance covered in ES, divided by* c.

$$\tau \;=\; d_4/c \qquad \textit{(Euclidean time).} \tag{4}$$

Equation (4) tells us that Euclidean time is not a fundamental quantity, but only a subordinate quantity derived from covered distance. Distance and speed are more significant than time! So, we suggest to define new units for distance, speed, and time: All distances should be specified in "light seconds", c in its own new unit to be given by the community, and τ in "light seconds per this new unit". We do prefer the term "Euclidean spacetime" over "Euclidean space" because covered distance relates to Euclidean time.

For each object, we define a 4D vector "flow of time"

$$\boldsymbol{\tau} \;=\; d_4\,\boldsymbol{u}/c^2 \qquad \textit{(Flow of time),} \tag{5}$$

where $\boldsymbol{u}$ is the Cartesian ES velocity of the object and $\boldsymbol{u}/c$ is a unit 4D vector specifying the current direction of motion of the object. The Cartesian ES velocity $\boldsymbol{u}$ has four components $u_i = \mathrm{d}d_i/\mathrm{d}t$. From Equation (3b), we get

$$u_1^2 + u_2^2 + u_3^2 + u_4^2 \;=\; c^2 \tag{6}$$

From Equations (5) and (6), we can convince ourselves that there is indeed $\tau = |\boldsymbol{\tau}| = d_4/c$. For each observed object, Euclidean time flows in a 4D direction equal to its direction of motion. The projection of the object's 4D vector "flow of time" to an observer's direction of motion yields *its* motion in *his* Einstein time. Because of this projection, Einstein time provides less information than Euclidean time! Einstein time hides that there is a unique 4D vector "flow of time" for each object.

ES is an open 4D manifold with a Euclidean metric. We can describe ES either in four hyperspherical coordinates $(\phi_1, \phi_2, \phi_3, r)$, where each ϕ_i is a hyperspherical angle and r is *radial distance* from an origin,—or in four *symmetric*, Cartesian coordinates (d_1, d_2, d_3, d_4), where each d_i is *axial distance* from an origin. Be aware that in ES distance isn't covered as a function of independent time. **Only by covering distance is Euclidean time passing by.** The drawback of ER is that we must

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get used to a different meaning of time: *Euclidean time isn't a quantity enabling motion, but a quantity resulting from motion.*

Hyperspherical coordinates are good for grasping the big picture in cosmology. We claim: The Big Bang injected a huge amount of energy into ES all at once at what we take as "origin O". It also provided an overall radial momentum: Shortly after the Big Bang, all energy moved radially away from O. Today, some energy is moving transversally because of energy conversion events, such as plasma recombination and supernovae.

Cartesian ES coordinates serve as a "master reference frame": An observer's reality is only created by projecting the coordinates d_i orthogonally to his proper 3D space and to his proper flow of time. The symmetry of all d_i supports the idea of natural units. "Space" and "time" in everyday life are just different interpretations of distance covered in ES. There is

$$d_1 = r \cos\phi_1 \tag{7a}$$

$$d_2 = r \sin\phi_1 \cos\phi_2 \tag{7b}$$

$$d_3 = r \sin\phi_1 \sin\phi_2 \cos\phi_3 \tag{7c}$$

$$d_4 = r \sin\phi_1 \sin\phi_2 \sin\phi_3 \tag{7d}$$

In our ES diagrams, we often choose Cartesian coordinates in which an object starts moving from some origin P other than O. We assume: *Each observer moves only in his axis* d_4*; each observed object moves only in its axis* d_4'. Below our ES diagrams, we project ES to an observer's proper 3D space. Here we are free to label the three axes that we project to. In most cases, we assume: There is relative motion only in d_1 and d_4. Our ES diagrams then display d_1 and d_4, while our 3D projections display d_1. The projections to d_1, d_2, d_3 and to d_4 are orthogonal. We don't replace the concept of space because d_1, d_2, d_3 are equal to x_1, x_2, x_3. We replace the concept of time because there is $t = \tau$ only for clocks moving in the axis d_4. If a clock moves in a direction d_4' other than d_4, its distance covered in ES is projected to an observer's axis d_4. *Such a clock is slow in his Einstein time, but Euclidean time flows at the same rate for him (in* d_4*) and for the observed clock (in* d_4'*).*

4. Geometric Effects in Euclidean Spacetime

We consider the same two rockets as in Figure 1. Observer R (or B) in the rear end of the red rocket r (or else blue rocket b) uses d_1, d_2, d_3, d_4 (or else d_1', d_2', d_3', d_4') as coordinates. d_1, d_2, d_3 span the 3D space of R, and d_1', d_2', d_3' span the 3D space of B. d_4 relates to the Einstein time of R, and d_4' relates to the Einstein time of B. The rockets move relative to each other in either 3D space at the constant speed v_{3D} (Figure 2 bottom). As just explained, all 3D motion is in d_1 (or else d_1'). Our ES diagrams (Figure 2 top) must fulfill these requirements: (1) According to our first postulate, both rockets must move at the speed c. (2) Our second postulate must be fulfilled. (3) Both rockets started at the same point P. There is only one way of how to draw our ES diagrams: We must rotate the two reference frames with respect to each other. Only a rotation guarantees full symmetry, so that the laws of physics have the same form in the 3D spaces of R and of B.

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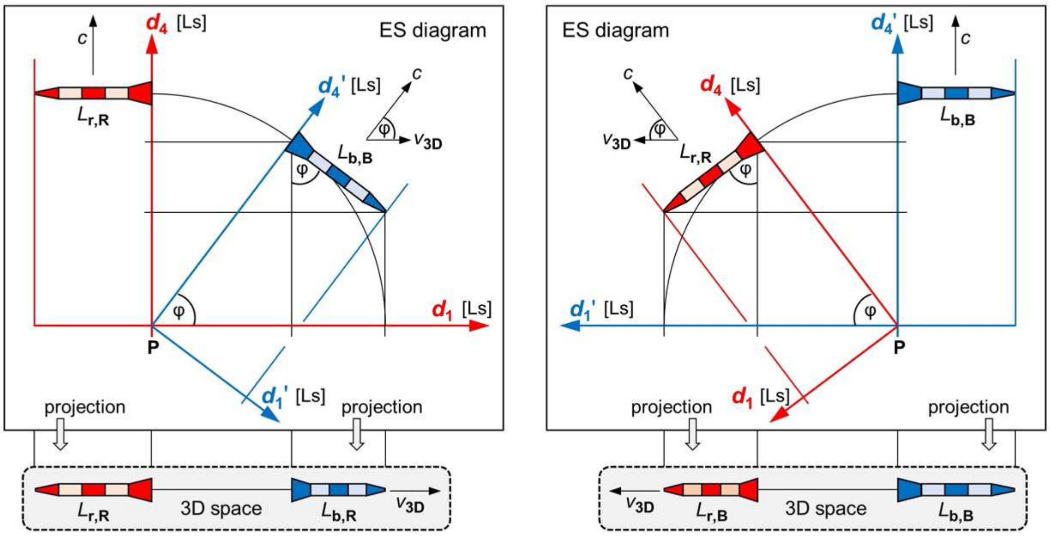

Figure 2. ES diagrams and 3D projections for two identical rockets. All axes are in Ls (light seconds). **Top left and top right:** In the ES diagrams, both rockets are moving at the speed c, but in different directions. **Bottom left:** Projection to the 3D space of R. The relative speed is v_{3D}.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

We now verify two effects in ES: (1) Since B moves relative to R, the proper 3D space of B is rotated with respect to the proper 3D space of R *causing length contraction.* (2) Since B moves relative to R, the time of B and the time of R flow in different directions *causing time dilation.* We define $L_{i,R}$ (or $L_{i,B}$) as length of the rocket i as measured by the observer R (or else B). In a first step, we project the blue rocket in Figure 2 top left to the axis d_1.

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

$$L_{b,R} = \gamma^{-1} L_{b,B} \quad \textit{(Length contraction)}, \quad (9)$$

where $\gamma = (1 - v_{3D}^2/c^2)^{-0.5}$ is the same Lorentz factor as in SR. The blue rocket appears contracted to observer R by the factor γ^{-1}.

We now ask: Which distances will R observe in his axis d_4? For the answer, we mentally continue the rotation of the blue rocket 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 "is suppressed" (disappears) for R. In a second step, we project the blue rocket in Figure 2 top left to the axis d_4.

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

$$d_{4,B} = \gamma^{-1} d'_{4,B} \quad (11)$$

where $d_{4,B}$ (or $d'_{4,B}$) is the distance that B has moved in d_4 (or else d'_4). With $d'_{4,B} = d_{4,R}$ (full symmetry in ES) and the substitutions $d_{4,B} = ct_B$ and $d_{4,R} = ct_R$, we get

$$t_R = \gamma\, t_B \quad \textit{(Einstein time dilation)}, \quad (12)$$

where t_R (or t_B) is the distance that R (or else B) has moved in the Einstein time t of R. Equation (12) tells us that the clock of B is slow with respect to R in the variable t, and not in t'. There is no Euclidean time dilation because τ is absolute ($\tau_R = \tau_B$).

Despite the Euclidean metric in ES, the Lorentz factor γ is recovered in Equations (9) and (12). This is no surprise because Weyl showed that the Lorentz group is generated by 4D rotations [17]. Gersten [11] demonstrated that the Lorentz transformation is equivalent to an SO(4) rotation in a "mixed space" x_1, x_2, x_3, ct'. While this is mathematically correct, such a "mixed space" doesn't make sense physically. Yet it is a hint that Einstein time has an issue! In ER, $c\tau$ of an observed object (and not ct') is taken as the fourth coordinate of that object. The SO(4) rotation now takes place in d_1, d_2, d_3, d_4 (Figure 2). The Lorentz factor γ is recovered in an observer's reality by projecting ES to d_1, d_2, d_3 and to d_4.

And the Lorentz transformation? It is recovered, together with the Lorentz factor γ, whenever the observer ignores the richness of τ and holds on to t. Since his selected concept of time (τ or t) has no effect on how clocks are running, it also has no effect on the physics involved. **SR and all theories based on SR work equally well in either concept of time.** Yet if the observer selects t, he won't be able to grasp the big picture in cosmology and quantum mechanics (see Sect. 5). So, the issue in Einstein time is real!

In order to understand how an acceleration in 3D space manifests itself in ES, let us assume that the blue rocket b in Figure 3 accelerates in the axis d_1. According to Equation (6), the speed u_1 of b must then increase at the expense of its speed u_4. *So, b is rotating and moving along a curved trajectory in Cartesian ES coordinates.* Any acceleration of an object in 3D space relates to a 4D rotation and a curved trajectory in Cartesian ES coordinates.

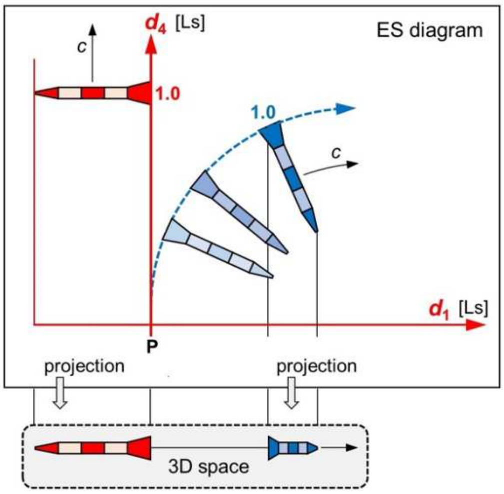

Figure 3. ES diagram and 3D projection for two identical rockets. **Top:** In the ES diagram, the red rocket moves in the steady axis d_4. The blue rocket accelerates in the axis d_1. **Bottom:** Projection to the 3D space of R. The red rocket is "at rest". The blue rocket accelerates against the red rocket.

Up next, we demonstrate that the ES geometry can also improve our understanding of gravitation. Let us imagine that Earth is located to the right of the blue rocket in Figure 3 bottom. We assume that the blue rocket is accelerating in the gravitational field of Earth. Equation (6), which we applied for drawing Figure 3, tells us: If an object accelerates in the axis d_1 of an observer, it automatically decelerates in his axis d_4 (in his flow of time).

Gravitational waves [18] support the idea of GR that gravitation would be a property of spacetime, but they might be predicted by ER, too. Particle physics is still considering gravitation a force that has not yet been unified with the other three forces of physics. We claim: *Curved trajectories in Cartesian ES coordinates replace curved spacetime in GR.* Equation (6) is the key equation which relates any motion in d_1, d_2, d_3 to a motion in d_4. To support our claim, we now use Cartesian ES coordinates to calculate the Einstein time dilation in the gravitational field of Earth. Let A and B be two identical clocks far away from Earth. They are synchronized, next to each other, and move in the axis d_4 at the speed c. Clock B is then allowed to approach Earth in the axis d_1 of A. The kinetic energy of B (mass m) is

$$\frac{1}{2}\, m\, u_{1,\mathrm{B}}^2 \;=\; G\, M\, m/r \;, \tag{13}$$

where $u_{1,\mathrm{B}}$ is the speed of B in the axis d_1 of A, G is the gravitational constant, M is the mass of Earth, and r is the distance of B to Earth's center. By applying Equation (6), we get

$$u_{1,\mathrm{B}}^2 + u_{4,\mathrm{B}}^2 \;=\; 2\, G\, M/r + u_{4,\mathrm{B}}^2 \;=\; c^2 \tag{14}$$

$$u_{4,\mathrm{B}}^2/c^2 \;=\; 1 - 2\,G\,M/(rc^2) \tag{15}$$

where $u_{4,\mathrm{B}}$ is the speed of B in the axis d_4 of A. With $u_{4,\mathrm{B}} = \mathrm{d}d_{4,\mathrm{B}}/\mathrm{d}t_\mathrm{A}$ and $c = \mathrm{d}d_{4,\mathrm{B}}/\mathrm{d}t_\mathrm{B}$ (there is no steady axis d_4', but B keeps moving at the speed c), we get

$$\mathrm{d}t_\mathrm{B} \;=\; (1 - 2\,G\,M/(rc^2))^{0.5}\,\mathrm{d}t_\mathrm{A} \tag{16a}$$

$$\mathrm{d}t_\mathrm{A} \;=\; \gamma_\mathrm{grav}\,\mathrm{d}t_\mathrm{B} \qquad \textit{(Gravitational Einstein time dilation)}, \tag{16b}$$

where $\mathrm{d}t_\mathrm{B}$ is the distance that B has moved in the Einstein time t of A, while A itself has moved the distance $\mathrm{d}t_\mathrm{A}$. The dilation factor $\gamma_\mathrm{grav} = (1 - 2GM/(rc^2))^{-0.5}$ is the same as in GR [2]. The value of γ_grav won't change if B suddenly stops its motion relative to Earth. If clock B returns to A, the time displayed by B will be behind the time displayed by A. In GR, this effect is due to a curved spacetime. Applying Equation (6) in Equation (14) indicates: In ER, this effect is due to a curved trajectory of B which is projected to the axis d_4 of A.

We finish this section by discussing three instructive paradoxes (Figure 4). They demonstrate the benefit of our concept "distance" and of the projections from ES to an observer's reality. 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 some 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 some axis d_4. How can he ever detect the reflection? Problem 3: Earth revolves around the sun. We assume that the sun moves in some 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?

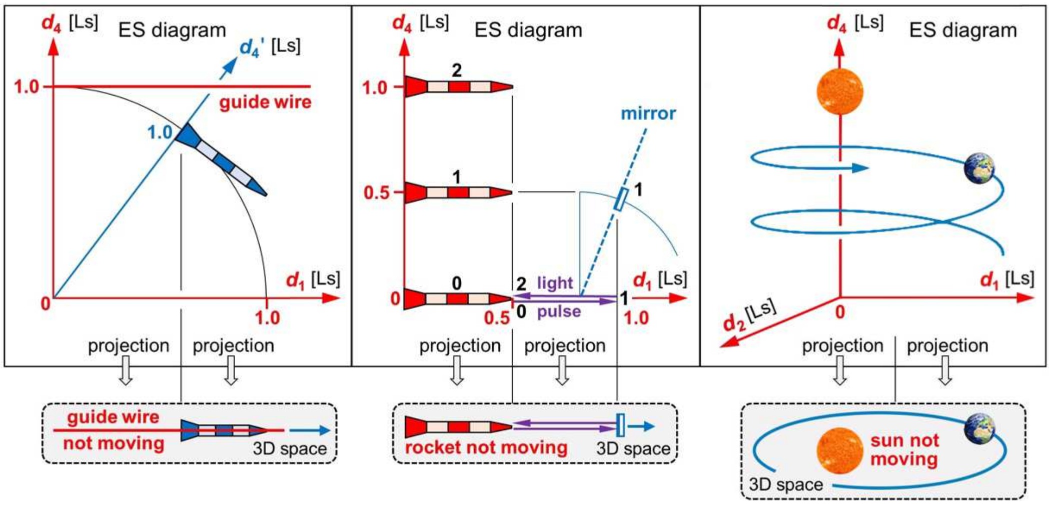

Figure 4. Graphical solutions to three geometric paradoxes. **Left:** A rocket moves along a guide wire. In 3D space, the guide wire remains within the rocket. **Center:** An observer in a rocket's tip tries to detect the reflection of a light pulse. Between two snapshots (0–1 or 1–2), rocket, mirror, 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. Yet just three distances of ES are observable! We solve all problems by projecting 4D ES orthogonally to 3D space (Figure 4). Then the axis d_4 is suppressed. *The projection tells us what an observer's reality is like because "suppressing* d_4*" is equivalent to "length contraction makes* d_4 *disappear".* Suppressed distance is felt as time. We easily verify in 3D space: The guide wire remains within the rocket; the light pulse is reflected back to the observer; the sun remains in the

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orbital plane of Earth. Other models [8–13] run into paradoxes because they don't project ES to an observer's reality.

5. Solving 15 Fundamental Mysteries of Physics

Why should we know about ER and the master frame ES if SR and GR work so well for each observer? In this section, we demonstrate that ER outperforms SR and GR in the understanding of time, time's arrow, mc^2, cosmology, and quantum mechanics.

5.1. Solving the Mystery of Time

Euclidean time is distance covered in ES, divided by c. *Time originates from each object rather than from my watch.* Because time can flow in countless 4D directions, the metaphor of "time running in a straight 1D line" is limited in scope. By contrast, there is no definition of Einstein time other than "what I read on my watch" (attributed to Einstein himself).

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 the distance covered in ES and c always have a positive value.

5.3. Solving the Mystery of mc^2

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

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

where $E_{\text{kin,3D}}$ is its kinetic energy in 3D space and mc^2 is its "energy at rest". SR doesn't tell us why there is a c^2 in the energy of objects that in SR never move at the speed c. ER gives us this missing clue and is thus superior to SR: *$E_{\text{kin,3D}}$ is an object's kinetic energy in the axes d_1, d_2, d_3 of an observer, mc^2 is its kinetic energy in* ***his*** *axis d_4, and γmc^2 is the sum of these energies—and likewise its kinetic energy in* ***its*** *axis d_4'.* The c^2 in Equation (17) tells us that everything is moving through ES at the speed c. In SR, we are also familiar with

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

where p is the total momentum of an object and $p_{3\text{D}}$ is its momentum in 3D space. ER is again superior to SR: After dividing Equation (18) by c^2, it becomes the vector addition of an object's momentum $p_{3\text{D}}$ in the axes d_1, d_2, d_3 of an observer and its momentum mc in **his** axis d_4. For observer R inside the red rocket (Figure 1 center or Figure 2), there is $E_{\text{kin,3D}} = 0$ and $p_{3\text{D}}^2 = 0$ for the red rocket, but $E_{\text{kin,3D}} > 0$ and $p_{3\text{D}}^2 > 0$ for the blue rocket.

5.4. Solving the Mystery of Relativistic Effects

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

5.5. Solving the Mystery of Gravitational Time Dilation

Equation (16b) tells us: The Einstein time of an object in a gravitational field passes by more slowly with respect to an observer who is very far away from the center of this field. The object's curved trajectory in Cartesian ES coordinates is projected to the observer's proper 3D space (here the object accelerates) and to his proper flow of time (here it decelerates).

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

Now we are ready for our new model of cosmology based on ER. There is no need to create ES. It exists just like numbers. Because of some reason that we don't know, there was a Big Bang. In

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today's model of cosmology, it makes no sense to ask *where* it occurred: Because space inflated from a singularity, it occurred everywhere. In ES, the Big Bang can be localized at what we take as origin O. The Big Bang injected a huge amount of energy into ES all at once. It also provided an overall radial momentum.

Right after the Big Bang, the concentration of energy was extremely high 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, electromagnetic radiation was emitted that we observe as CMB today [19]. At temperatures of roughly 3,000 K, hydrogen atoms formed and the universe became transparent for the CMB. In today's model of cosmology, this stage was reached about 380,000 years "after" the Big Bang. In ER, these are 380,000 light years "away from" the Big Bang. The value "380,000" still needs to be recalculated because we claim that there was no cosmic inflation (see Sect. 5.9).

Figure 5 left shows the ES diagram for observers on Earth (here Earth is moving in d_4). Most energy is moving radially: It keeps the radial momentum provided by the Big Bang. The CMB is moving transversally to the axis d_4: It can't move in d_4 as it already moves in d_1 at the speed of light. *All energy is confined to an expanding 4D hypersphere; most energy is confined to its 3D hypersurface.* We now explain three striking observations regarding the CMB: (1) It is nearly isotropic because it was created equally in d_1, d_2, d_3. Cosmic inflation is not needed! (2) The temperature of the CMB is very low because of a very high recession speed v'_{3D} (see Sect. 5.10) and thus a very high Doppler redshift. (3) We observe the CMB today because it started moving at a speed $c' \ll c$ in a very dense medium.

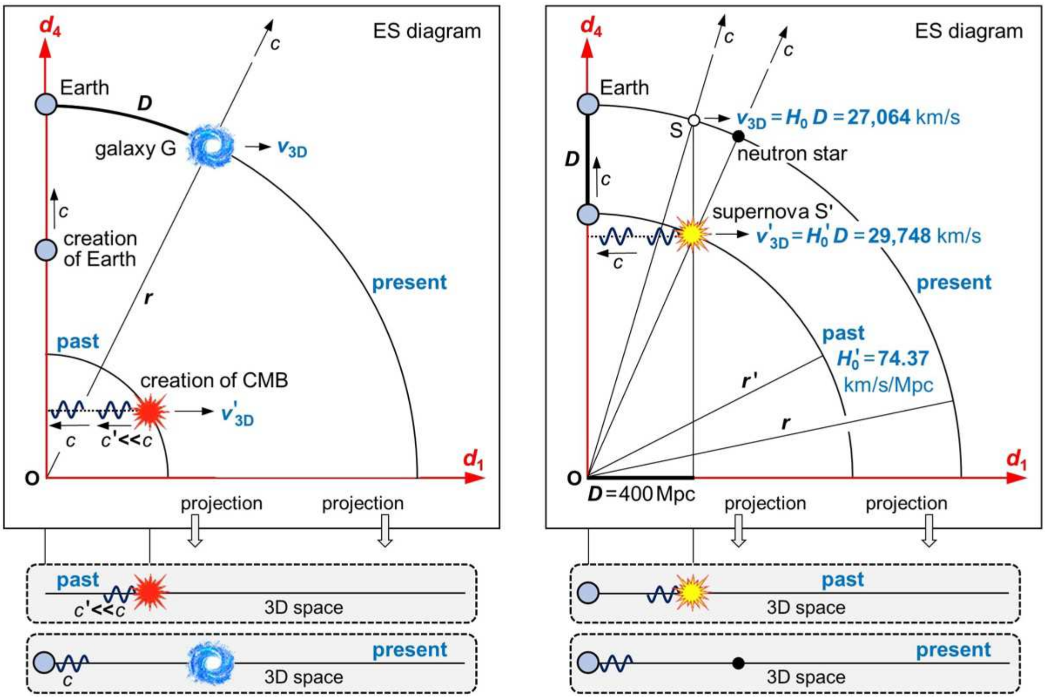

Figure 5. ES diagrams and 3D projections (not to scale) for solving the three mysteries 5.6, 5.7, and 5.10. The displayed circular arcs are part of a 3D hypersurface, which is expanding in ES at the speed c. **Left:** The CMB is isotropic because it was created equally in d_1, d_2, d_3 (d_2, d_3 not shown here). The CMB has a very low temperature because of a very high v'_{3D}. We observe the CMB today because it started moving at a speed $c' \ll c$. **Right:** A supernova S′ occurred when the radius r' was smaller than today's radius r. Team B measures S′ in a distance $d_1 = D$. Earth moved the same D, but in d_4, when the light of S′ arrives. A supernova S occurring today (same D) recedes slower than S′.

5.7. Solving the Mystery of Hubble's Law

Figure 5 left shows a galaxy G, which is moving away from the origin O and from Earth. The recession speed v_{3D} relates to the distance D as c relates to the radius r.

$$v_{3D} = D\,c/r = H_0\,D \qquad (\textit{Hubble's law}), \tag{19}$$

where $H_0 = c/r$ is the Hubble constant, c is in km/s, and r is in Mpc. There it is! Equation (19) is Hubble's law [20]: *The farther a galaxy, the faster it is moving away from Earth.*

5.8. Solving the Mystery of the Flat Universe

ES is projected orthogonally to an observer's proper 3D space. So, this 3D space has no curvature in the fourth dimension. Each observer experiences a flat 3D universe.

5.9. Solving the Mystery of Cosmic Inflation

Many physicists believe that an inflation of space in the early Universe [21,22] would explain the isotropic CMB, the flatness of the observed universe, and large-scale structures (inflated from quantum fluctuations). We showed in Sects. 5.7 and 5.8 that ES can explain the first two of these observations. It also explains the third observation if we only assume that the impacts of early quantum fluctuations have been expanding at the speed of light. ***Cosmic inflation is a redundant concept.***

5.10. Solving the Mystery of Competing Hubble Constants

There are several methods of calculating the Hubble constant H_0, but unfortunately the results vary from one method to another. Here we consider measurements of the CMB made with the *Planck space telescope* [23]. We compare them with calibrated distance ladder techniques (distance and redshift of celestial objects) using the *Hubble space telescope* [24]. We now explain why the values of H_0 obtained by the two teams don't match within the specified error margins. According to team A [23], there is $H_0 = 67.66 \pm 0.42$ km/s/Mpc. According to team B [24], there is $H_0 = 73.52 \pm 1.62$ km/s/Mpc.

Team B made efforts to minimize the error margin by optimizing the distance measurements. Yet, as we will prove now, misinterpreting the redshift measurements causes a systematic error in team B's calculation of H_0. We assume that 67.66 km/s/Mpc would be today's value of H_0. We simulate a supernova at a distance of $d_1 = D = 400$ Mpc. If this supernova occurred today (S in Figure 5 right), Equation (19) would give us the recession speed

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

$$z = \Delta\lambda/\lambda_0 \cong v_{3D}/c = 0.0903, \tag{21}$$

where the redshift parameter z tells us how any wavelength λ_0 of the supernova's light is either *passively* stretched by an expanding space (team B)—or how λ_0 is redshifted by the Doppler effect of objects that are *actively* receding in ES (our model).

In this and the next paragraph, we demonstrate that team B measures a higher value z', and thus calculates a higher value v'_{3D}, and thus calculates a higher value H'_0 (which is not the same as H_0). In Figure 5 right, there is one circle called "past", where the supernova S′ occurred that team B is measuring, and a second circle called "present", where its light arrives on Earth. Today, this supernova has turned into a neutron star. Because everything is moving at the speed c, Earth moved the same distance D, but in the axis d_4, when the light of S′ arrives. Hence, team B is receiving data from an ancient time $\tau' = 1/H'_0$ when there was a smaller radius r' and a larger Hubble constant H'_0.

$$1/H'_0 = r'/c = (r - D)/c = 1/H_0 - D/c, \tag{22}$$

$$H'_0 = 74.37 \text{ km/s/Mpc}. \tag{23}$$

Because of this higher value and of Equation (19), all data measured and calculated by team B relate to a higher 3D speed $v'_{3D} = 29{,}748$ km/s for the same D. Because of $z' \cong v'_{3D}/c$, this is going to happen: Team B measures a redshift of $z' = 0.0992$, which is indeed higher than 0.0903. Because of this higher value of z', team B will calculate $v'_{3D} = 29{,}748$ km/s from $z' \cong v'_{3D}/c$ and thus $H'_0 = 74.37$ km/s/Mpc from Equation (19). Hence, team B will conclude that 74.37 km/s/Mpc would be today's value H_0. In truth, team B ends up with a value H'_0 of the past because it isn't aware of Equation (22) and of the ES geometry.

For a shorter distance of $D = 400$ kpc, Equation (22) tells us that team B's Hubble constant H'_0 deviates from team A's Hubble constant H_0 by only 0.009 percent. Yet when plotting v'_{3D} versus D for various distances (we chose 50 Mpc, 100 Mpc, 150 Mpc, ..., and 450 Mpc as we didn't have the raw distance data used by [24]), the resulting slope (team B's Hubble constant) is 8 to 9 percent higher than team A's Hubble constant. We kindly ask team B to improve its calculation by eliminating the systematic error in the redshift measurement. It must adjust the calculated speed v'_{3D} to today's speed v_{3D} by converting Equation (22) to

$$H'_0 = H_0\, c \,/\, (c - H_0\, D) = H_0 \,/\, (1 - v_{3D}/c), \tag{24}$$

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

We conclude: *The redshift is caused by the Doppler effect of objects that are actively receding in ES.* Matching the two competing values of H_0 (team B's published value is indeed 8 to 9 percent higher than team A's value) is probably the strongest proof of our theory. Team A's value is correct: $H_0 = 67 - 68$ km/s/Mpc. If the 3D hypersurface in Figure 5 has always been expanding at the speed c, the total time having elapsed since the Big Bang would be equal to $1/H_0$, which is 14.5 billion years rather than 13.8 billion years [25]. The adjusted age would explain the existence of stars as old as 14.5 billion years [26].

Of course, team B is well aware of the fact that the supernova's light was emitted in the past. Yet in the Lambda-CDM model, all that counts is the timespan Δt during which light is traveling from the supernova to Earth. Along the way, its wavelength is passively stretched by expanding space. So, the total redshift is only developing during the journey to Earth. We can put it this way: The redshift parameter z' starts from zero and increases continuously during the journey to Earth. The fact that the supernova occurred long ago in the past at a time t_s is irrelevant for team B's calculation.

In ER, the moment τ_s (when a supernova occurs) is significant, but the timespan $\Delta\tau$ (during which light is traveling to Earth) is irrelevant. The wavelength of the supernova's light is initially redshifted by the Doppler effect. During its journey to Earth, the parameter z' remains constant. Here we can put it this way: The redshift parameter z' is tied up at the moment τ_s "in a package" and sent to Earth, where it is measured. In the Lambda-CDM model, space itself is expanding. In ER, a 3D hypersurface (actively receding energy, not space!) is expanding in ES. ***Expansion of space is a redundant concept.***

5.11. Solving the Mystery of Dark Energy

The CDM model of cosmology assumes an expanding space to explain the distance-dependent recession of celestial objects. Meanwhile, it has been extended to the Lambda-CDM model, where Lambda is the cosmological constant. Cosmologists are now favoring an accelerating expansion [27,28] over a uniform expansion. This is because the calculated recession speeds deviate from values predicted by Equation (19) if H_0 is taken as an averaged constant. The deviations increase with distance D and are compensated by assuming an accelerating expansion of space. Such an acceleration would stretch the wavelength even more and thus increase the recession speeds according to Equation (21).

Our model gives a much simpler explanation for the deviations from Hubble's law: Because of $H_0 = c/r = c/d_4 = 1/\tau$, the Hubble constant H_0 is a function $H_0(\tau)$. H'_0 from every past is higher than today's value. The older the redshift data are, the more will H'_0 deviate from today's value H_0, and the more will v'_{3D} deviate from v_{3D}. The small white circle in Figure 5 right helps us understand these deviations: If a new supernova S occurred today at the same distance $D = 400$ Mpc as the shown supernova S′ in the past, S would recede slower (27,064 km/s) than S′ (29,748 km/s) just because of the different values of H_0 and H'_0. As long as the ES geometry is unknown, higher redshifts are attributed to an accelerating expansion of space. Now that we know about the ES geometry, we can attribute higher redshifts to data from deeper pasts.

We conclude that any expansion of space—uniform as well as accelerating—is only virtual. There is no accelerating expansion of the Universe even if a Nobel Prize was given "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae" [29]. This phrasing actually contains two misconceptions: (1) In the Lambda-CDM model, the term "Universe" implies space, but space isn't expanding at all. (2) There is a uniform expansion of a 3D hypersurface (actively receding energy), but no "accelerating expansion" whatsoever.

The term "dark energy" [30] was coined to come up with a cause for an accelerating expansion of space. We just explained that there is no expansion of space. So, dark energy is an artifact of Einstein time. ***Dark energy is a redundant concept.*** It has never been observed anyway. Radial momentum provided by the Big Bang drives galaxies away from the origin O. They are driven by themselves rather than by dark energy.

Table 1 summarizes huge differences in the meaning of Big Bang, Universe/universe, space, and time. In the Lambda-CDM model, the Big Bang was the beginning of the Universe. In our model, the Big Bang was the injection of energy into ES. In the Lambda-CDM model, Universe (capitalized) is all space, all time, and all energy. In our model, universe is the proper 3D space of one observer. In the Lambda-CDM model, spacetime is curved. In our model, trajectories of objects are curved in Cartesian ES coordinates. There is also a significant difference regarding the underlying theory of relativity: GR isn't compatible with quantum mechanics; ER is compatible with quantum mechanics.

Table 1. Comparing the Lambda-CDM model with our 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 in today's space.	Big Bang can be localized at an origin O of ES.
Big Bang occurred about 13.8 billion years ago.	Big Bang occurred about 14.5 billion years ago.
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: proper 3D space of one observer.
Space is inflating and expanding.	Most energy is receding radially in ES.
Space is driven by dark energy.	Galaxies are driven by radial momentum.
Spacetime is curved.	Trajectories of objects are curved.
"Time is what I read on my watch." (A. Einstein)	Time is radial distance r from O divided by c.
GR isn't compatible with quantum mechanics.	ER is compatible with quantum mechanics.

5.12. Solving the Mystery of the Wave–Particle Duality

We can't tell which solved mystery is the most important one. Yet the wave–particle duality has certainly kept physicists busy since it was first discussed by Niels Bohr and Werner Heisenberg [31]. The Maxwell equations tell us that electromagnetic waves are oscillations of an electromagnetic field that move through 3D space at the speed of light c. In some experiments, objects behave like "waves" (electromagnetic wave packets). But in other experiments, the same objects behave like particles. In today's physics, an object can't be both at once because waves distribute energy in space over time, while the energy of particles is localized in space at a given time. This is why we added our third postulate: All energy is "wavematter" (electromagnetic wave packet and matter in one). By combining our concepts of distance and wavematter, we now demonstrate: *Waves and particles are actually the same thing (energy), but seen from two perspectives.*

Figure 6 illustrates in Cartesian ES coordinates what our new concept of wavematter is all about. If I observe a wavematter (we call it the "external view"), this wavematter comes in four orthogonal dimensions: It propagates in my axis d_1 at some speed $v_{3D} \le c$, and it oscillates in my axes d_2 (electric field) and d_3 (magnetic field); propagating and oscillating are functions of Euclidean time τ (related to my fourth axis d_4). So, I can observe how this wavematter is propagating and oscillating: *I deem it wave.*

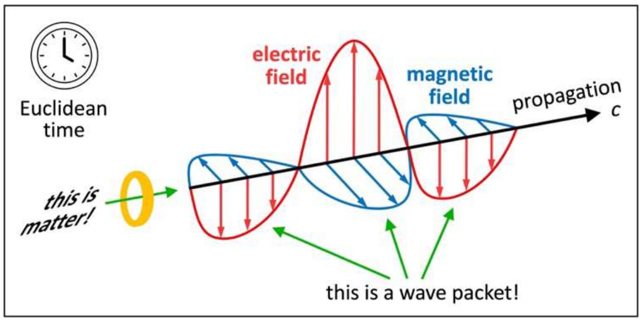

Figure 6. Concept of wavematter. Artwork illustrating how one object can be deemed wave or matter. Wavematter comes in four orthogonal dimensions: propagation, electric field, magnetic field, and Euclidean time. Each wavematter deems itself matter at rest (internal or in-flight view). If it is observed by some other wavematter (external view), it is deemed wave.

From its own perspective (we call it the "internal view" or the "in-flight view"), each wavematter propagates in its axis d_4' at the speed c. Yet because of length contraction at the speed c, the axis d_4' is suppressed for this wavematter. For this reason, its own propagating disappears for itself: *It deems itself matter at rest.* It still observes the other objects propagating and oscillating in its proper 3D space as it keeps on feeling Euclidean time, while it is invisibly propagating in its axis d_4'. We conclude that there is an external view and an internal view of each wavematter. In today's physics, there is no reference frame moving at the speed c and thus no internal view of a photon. Be aware that "wavematter" isn't just another word for the duality, but a generalized concept of energy disclosing *why* there is a wave–particle duality in an observer's proper 3D space.

As an example, we now investigate the symmetry in three wavematters WM_1, WM_2, and WM_3. We assume that they are all moving away from the same point P in ES, but in different directions (Figure 7 top left). d_1, d_2, d_3, d_4 are Cartesian coordinates in which WM_1 moves only in d_4. Hence, d_4 is that axis which WM_1 deems time multiplied by c, and d_1, d_2, d_3 span WM_1's 3D space (Figure 7 bottom left). As the axis d_4 disappears because of length contraction, WM_1 deems itself matter at rest (M_1). WM_3 moves orthogonally to WM_1. d_1', d_2', d_3', d_4' are Cartesian coordinates in which WM_3 moves only in d_4' (Figure 7 top right). In this case, d_4' is that axis which WM_3 deems time multiplied by c, and d_1', d_2', d_3' span WM_3's 3D space (Figure 7 bottom right). As the axis d_4' disappears because of length contraction, WM_3 also deems itself matter at rest (M_3).

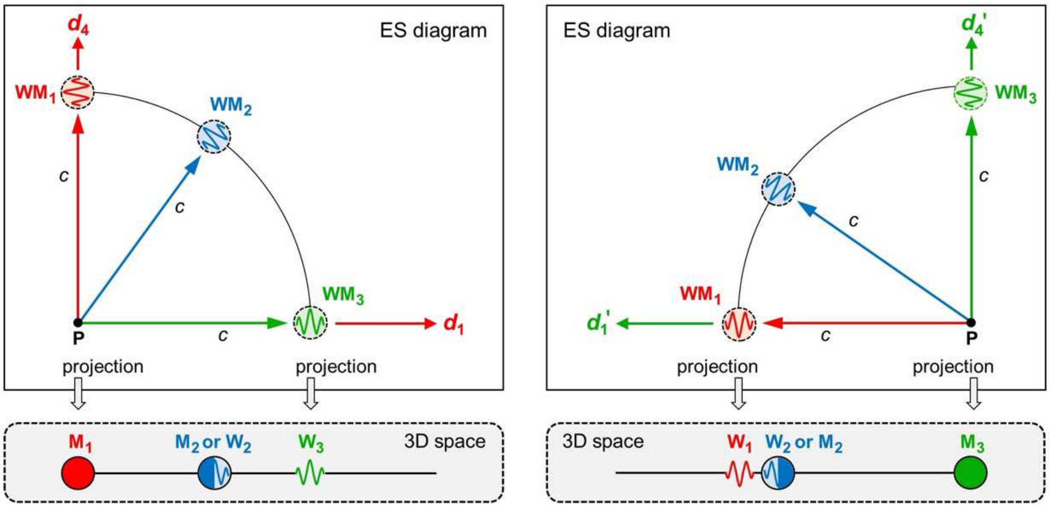

Figure 7. ES diagrams and 3D projections for three wavematters. **Top left:** ES in coordinates where WM_1 moves in d_4. **Top right:** ES in coordinates where WM_3 moves in d_4'. **Bottom left:** Projection to WM_1's 3D space. WM_1 deems itself matter at rest (M_1) and WM_3 wave (W_3). **Bottom right:** Projection to WM_3's 3D space. WM_3 deems itself matter at rest (M_3) and WM_1 wave (W_1).

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Yet how do WM_1 and WM_3 move in each other's view? We must fulfill our first two postulates and the requirement that they both started at the same point P. There is only one way of how to draw our ES diagrams: We must rotate the two reference frames with respect to each other. Only a rotation guarantees full symmetry, so that the laws of physics have the same form in the 3D spaces of WM_1 and of WM_3. We can put it this way: WM_3's 4D motion "swings completely" (rotates by an angle of 90°) into WM_1's 3D space, so that WM_1 deems WM_3 wave (W_3). Regarding WM_2, we split its 4D motion into a motion parallel to WM_1's motion (internal view) and a motion orthogonal to WM_1's motion (external view). So, WM_1 can deem WM_2 either matter (M_2) or wave (W_2).

The secret to understanding our new concepts "distance" and "wavematter" is all in Figure 7. Here we see how they go hand in hand: We claim the symmetry of all four Cartesian coordinates in ES and, on top of that, the symmetry of waves and matter. *What I deem wave, deems itself matter.* Just as distance is spatial and temporal distance in one, so is wavematter wave and matter in one. Here is a compelling reason for this unique claim of our theory: Einstein taught that energy is equivalent to mass. Full symmetry of waves and matter is a consequence of this equivalence. As the axis d_4 disappears because of length contraction, the energy in a propagating wave "condenses" to mass in matter at rest.

In a double-slit experiment, an observer detects coherent waves which pass through a double-slit and produce some pattern of interference on a screen. He observes wavematters from ES whose 4D motion "swings completely" (rotates by an angle of 90°) into his proper 3D space. He deems all these wavematters waves because he isn't tracking through which slit each wavematter is passing. If he did, the interference pattern would disappear immediately. So, 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 itself ("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. So, we must interpret the photoelectric effect from the *internal* view of each wavematter. Here its view is crucial! It behaves like a particle, which is commonly called "photon".

The wave–particle duality is also observed in matter, such as electrons [32]. According to our third postulate, electrons are wavematter, too. From the internal view (if I track them), electrons are particles: "Which slit will I go through?" From the external view (if I don't track them), electrons behave more like waves. Because I automatically track slow objects, I deem all macroscopic wavematters matter: Their speed in my 3D space is rather low compared with the speed of light thus favoring the internal view. This justifies drawing solid rockets and celestial objects in most of our ES diagrams.

5.13. Solving the Mystery of Quantum Entanglement

The term "entanglement" [33] was coined by Erwin Schrödinger when he published his comment on the Einstein–Podolsky–Rosen paradox [34]. The three authors argued that quantum mechanics wouldn't provide a complete description of reality. John Bell proved that quantum mechanics is incompatible with local hidden-variable theories [35]. Schrödinger's word creation didn't solve the paradox, but demonstrates up to the present day the difficulties that we have in comprehending quantum mechanics. Several experiments have meanwhile confirmed that entangled particles violate the concept of locality [36–38]. Ever since has quantum entanglement been considered a non-local effect.

We will now "untangle" quantum entanglement *without* the concept of non-locality. All we need to do is discuss quantum entanglement in ES. Figure 8 displays two wavematters that were created at once at the same point P and move away from each other in opposite directions at the speed c. We claim that these wavematters are entangled. We assume that they are moving in the axes $+d_4$ and $-d_4$, respectively. If they are observed by a third wavematter that is moving in a direction other than $\pm d_4$, they are deemed two objects. This third wavematter can't understand how the entangled wavematters are able to communicate with each other in no time. This is again the external view.

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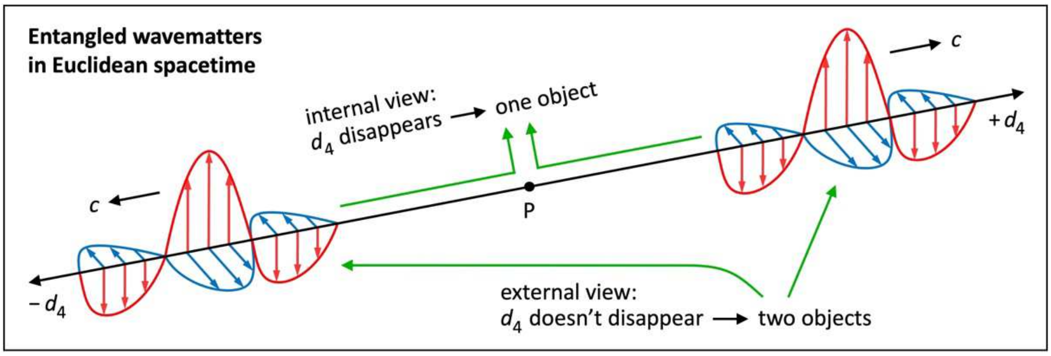

Figure 8. Quantum entanglement in ES. Artwork illustrating internal view and external view. For each displayed wavematter, the axis d_4 disappears because of length contraction. It deems its twin and itself one object (internal view). For a third wavematter that is moving in a direction other than $\pm d_4$, the axis d_4 doesn't disappear. It deems the displayed wavematters two objects (external view).

And here comes the internal (in-flight) view in ES: For each entangled wavematter in Figure 8, the axis d_4 disappears because of length contraction at the speed c. That is to say: In the projection to their *common* 3D space spanned by d_1, d_2, d_3, either wavematter deems itself at the very same position as its twin. *From either perspective, they are one object that has never been separated.* This is why they communicate with each other in no time! Entanglement is another strong evidence that everything is moving through ES at the speed c. Our solution to entanglement isn't limited to photons. Electrons or atoms can be entangled as well. They move at a speed $v_{3D} < c$ in my 3D space, but in their axis d_4 they also move at the speed c. We conclude: ***Even non-locality is a redundant concept.***

5.14. Solving the Mystery of Spontaneity

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 can't 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 proper 3D space—and this energy speeds off at once. In *absorption,* a photon is spontaneously absorbed by an atom. Today's physics can't 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 *annihilation.* We consider spontaneity another clue that everything is 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. Yet 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 (also known as the "baryon asymmetry"), it is assumed that more baryons than antibaryons must have been produced in the early Universe [39]. However, an asymmetry in pair production has never been observed.

Our theory offers a unique solution to the baryon asymmetry: Since each wavematter deems itself matter, there was matter in 3D space right after the Big Bang. Pair production isn't needed to create matter, and an asymmetry in pair production isn't needed to explain the baryon asymmetry. *There is much less antimatter than matter because antimatter is created only in pair production.* One may ask why wavematter doesn't deem itself antimatter, but this question is missing the point. Energy has two faces: wave and matter. "Antimatter" is matter, too, but with the opposite electric charge.

6. Conclusions

To this day, all attempts to unify GR and quantum mechanics have failed miserably. In Sects. 5.1 through 5.15, ER solves mysteries which SR and GR either haven't solved in 100+ years—or that have meanwhile been solved, but only by applying concepts (cosmic inflation, expansion of space, dark energy, non-locality) that we proved to be redundant. Now we let Occam's razor, a powerful tool in science, do its job: Because ER outperforms SR and GR, Occam's razor knocks out Einstein time and these four redundant concepts. The weakness in today's cosmology is: It uses two concepts of time (universal Euclidean time in all Big Bang models, Einstein time in all measurements). The weakness in today's quantum mechanics is: An observer's Einstein time can't describe things that are beyond any observation. *Egocentric Einstein time hides the big picture.*

Since SR and GR have been experimentally confirmed many times over, they are considered two of the greatest achievements of physics. We proved that their concept of time is flawed. Albert Einstein, one of the most brilliant physicists ever, wasn't aware of ER. It was a wise decision to award him with the Nobel Prize for his theory of the photoelectric effect [40] rather than for SR or GR. We campaign for ER as it penetrates to a deeper level. For the first time ever, mankind understands the nature of time: Time isn't a fundamental quantity, but distance covered in ES, divided by the speed of light. Imagine: The human brain is able to grasp the idea that our energy is moving through ES at the speed of light. *With that said, conflicts of mankind become all so small.*

ER solves 15 mysteries at once: (1) time, (2) time's arrow, (3) mc^2, (4) relativistic effects, (5) gravitational time dilation, (6) CMB, (7) Hubble's law, (8) flat universe, (9) cosmic inflation, (10) competing Hubble constants, (11) dark energy, (12) wave–particle duality, (13) quantum entanglement, (14) spontaneity, (15) baryon asymmetry. These 15 solutions are 15 confirmations of ER. It isn't unusual that new concepts give many answers at once. So, the answer to our title question is: Yes, physics benefits from Euclidean time. Einstein sacrificed absolute space and time. We sacrifice the absoluteness of waves and matter, but add a new absolute time derived from covered distance. Quantum leaps can't be planned. They just happen like the spontaneous emission of a photon. ☺

We introduced new concepts of time, distance, and energy: (1) There is absolute time. (2) Spatial and temporal distance aren't two, but one [41]. (3) Wave and matter aren't two, but one. We explained these concepts and confirmed how powerful they are. We can even tell the source of their power: *symmetry and beauty*. Once you have cherished this beauty, you will never let it go again. Yet to cherish it, you first need to give yourself a little push—accepting that an observer's reality is only created by projecting ES to his proper 3D space and to his proper flow of time. Questions like "Why would reality only be a projection?" must not be asked in physics. **The magic of "reality being a projection" compares to the magic of "reality being a probability function".** The latter is well accepted.

It looks like philosopher Plato was right with his *Allegory of the Cave* [42]: Mankind experiences a projection that is blurred because of quantum mechanics! We would be mistaken if we thought that the concepts of nature were on the same level as all the tangible realities perceived by us. Our advice: Think of a problem in physics and try to solve it in ER. We predict that ER covers gravitational waves, too. Our new concepts lay the groundwork for ER. Anyone is welcome to join us. Hopefully, physics will be improved.

Author Contributions: Markolf has a Ph.D. in physics and is a full professor at Heidelberg University, Germany. He studied in Frankfurt, Heidelberg, at UC San Diego, and Harvard. He found the issue in Einstein time, interpreted reality as "projection from a master frame", and contributed the concepts "distance" and "wavematter" that make ER compatible with quantum mechanics. He also drafted this paper. Siegfried taught physics and math at the Waldorf School in Darmstadt, Germany. He contributed most of the ES diagrams and solved the mystery of the competing Hubble constants.

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