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An Issue in Einstein's 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:** Predictions made by SR and GR are correct, but "Einstein time" (Einstein's concept of time, proper time of one observer) has an issue. SR and GR work well for one observer describing his reality and for another observer describing his reality, but they lack a "master reference frame" from which either one reality could be deduced *at once.* We replace Einstein time with "Euclidean time" (proper time of all objects/observers) and SR/GR with Euclidean relativity (ER). In Euclidean spacetime (ES), all energy is moving radially away from an "origin" (Big Bang) at the speed of light. For each object, time flows in a unique 4D direction related to its position. Unlike other ER models, we claim that an observer's reality is only created by projecting ES to his proper 3D space and to his proper flow of time. ER gives us the same Lorentz factor as in SR and the same gravitational time dilation as in GR. Curved trajectories in Cartesian ES coordinates replace "curved spacetime" in GR. 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.

Keywords: cosmology; hubble constant; gravitation; wave–particle duality; quantum entanglement

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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 transformation is recovered in our theory, and we explain why SR and GR work so well despite the issue in Einstein's concept of time. Cosmology and quantum mechanics work well *only if concepts are added* (cosmic inflation, expansion of space, dark energy, non-locality) that we prove to be redundant.

What most readers also don't see: It is because of this issue in Einstein's concept of time that GR is not compatible with quantum mechanics. We suggest three changes to the foundations of physics—new concepts of time, distance, and energy—that make relativity compatible with quantum mechanics. Honestly, isn't that reason enough to give our theory of Euclidean relativity (ER) a chance? We are asking this question because one editor informed us that some journals do not consider refutations of SR. Sorry, but why is that? Have SR and GR turned into a dogma that must not be questioned anymore? According to Karl Popper, a theory is scientific only if it is falsifiable [3]. Neither SR nor GR nor ER nor any concept of time is ever set in stone!

Here are five pieces of advice: (1) *Be willing to question today's concept of time.* Science can move forward only if we keep on questioning concepts. (2) *Do not take SR and GR for granted when evaluating ER.* Neither must we take the geocentric model for granted when evaluating the heliocentric model. Previous reviewers made a systematic error when they evaluated ER with concepts of SR and GR. ER is different. In ER, everything is moving at the speed of light. (3) *Evaluate ER reasonably.* SR is based on Einstein's concept of time. ER is based on Euclidean time. The Lorentz transformation of SR is recovered in ER. So, from this argument alone, there is no reason to favor one over the other. Yet ER solves mysteries which SR and GR haven't solved in 100+ years. (4) *Be patient and fair.* Do not expect us to address all of physics in this paper. SR and GR have been tested for 100+ years. We must hang on for ER to prove itself, too. (5) *Let illustrations inspire you.* Do not reject our figures. Artwork can assist the human brain to conceive of 4D.

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 (not positive-semidefinite) distance function. SR is often interpreted in Minkowski spacetime (MS) because Hermann 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] includes gravitation and 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 radially away from an origin at the speed of light. (2) The laws of physics have the same form in each observer's "reality" (orthogonal projection 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 the second SR 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 concept as objects at rest would then move in time at the speed "one second per one second". Our second postulate is the same as the first SR postulate, except that there is no limitation to inertial frames and that we distinguish ES from 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 in SR becomes an SO(4) rotation in ER [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 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 reality in our second postulate. *An observer's reality is only created by projecting ES to his proper 3D space and to his proper flow of time.*

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 derived from covered distance. The 4D speed of everything is $u_{4D} = c$. Immanuel Kant's philosophy [15] was inspired by Newton's physics. Check out whether ER can serve as the philosophical framework of cosmology and 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". § 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

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

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 a system K are transformed to the coordinates x'_1, x'_2, x'_3, t' of a system K′ by

$$x'_1 = \gamma\,(x_1 - v_{\mathrm{3D}}\,t) \tag{2a}$$

$$x'_2 = x_2 \tag{2b}$$

$$x'_3 = x_3 \tag{2c}$$

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

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

Eqs. (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 one observer. SR works well for R describing his reality and for B describing his reality, but SR lacks a "master reference frame" (superordinate system) from which either one reality could be deduced *at once.* This is caused by Einstein time being egocentric: In Eq. (1), Einstein time originates from the position of an observer. SR describes the reality of R in K, and then we must make a cut (draw a second Minkowski diagram) before SR can describe the reality of B in K′. We will demonstrate in Sect. 5 that 15 mysteries of physics can all be solved if we only assume that there is a universal time. *The egocentricity of Einstein time prevents physicists from grasping the big picture in cosmology and quantum mechanics, and from formulating the Theory of Everything.*

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 clocks of an observer B in K′ are slow with respect to the clocks of an observer R in K by the factor of γ. Time dilation has been experimentally confirmed. So, any alternative concept of time must recover Einstein time dilation by the same factor of γ. **Now watch out as the next thought is the birthplace of ER:** Most physicists aren't aware that there are two variables in which this time dilation can be stored. Both Einstein and Minkowski assumed that the clocks of B are slow with respect to R in the variable t'. There is another variable in which the clocks of B can be slow with respect to R: They can also be slow in the variable t, as we will explain next.

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.*

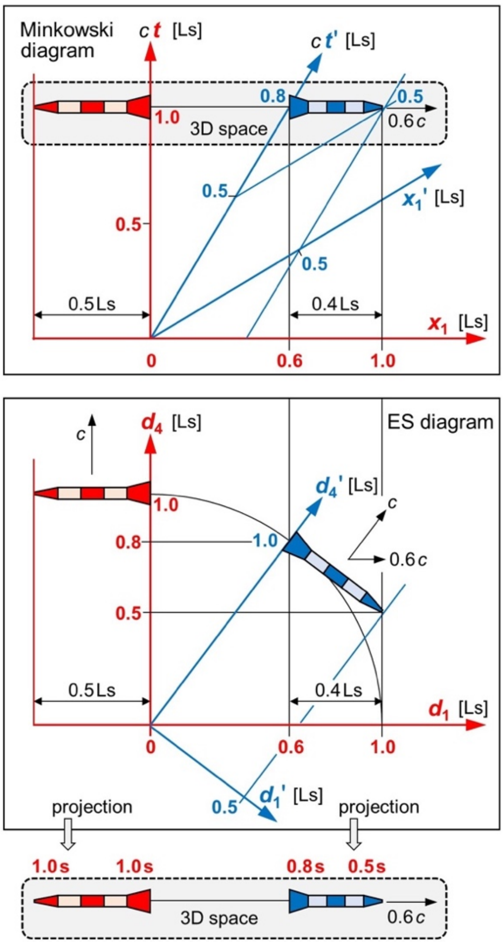

Figure 1. Minkowski diagram, ES diagram, and 3D projection for two identical rockets. **Top:** Minkowski diagrams display the reality of just one observer (here: of observer R who synchronizes all clocks in r and b). Our diagram doesn't display the reality of observer B because B would also synchronize all clocks in r and b. **Center:** ES diagrams display the realities of all observers. All own clocks are synchronous, while all moving clocks are asynchronous. **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. However, we must assume that B would also synchronize all clocks inside r and b. In order 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 all the measurements of both R and B seriously *at once*. Each observer claims just for himself (egocentric!) that all clocks are synchronized.

In experimental physics, we are used to take measurements of all observers seriously at once. This can be accomplished if we claim that each observer measures his own clocks as synchronous, while he measures all moving clocks as asynchronous. We arrive at this new concept of time by replacing the asymmetric axes x_1 and t in MS with symmetric distances d_1 and d_4 in ES (see Sect. 3), and then by rotating rocket b. We end up with an ES diagram (Figure 1 center), where 0.8 and 0.5 are measured by R. In MS, clocks inside b are slow with respect to R in t'. In ES, clocks inside b are slow with respect to R in d_4 (related to t).

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3. Introducing Euclidean Time and Euclidean Spacetime

There is also a more intuitive approach to Euclidean time. We imagine that all energy is in a 1D reality, which is the line of a circle around some absolute point (origin O). The circle is expanding at the speed c. *For an observer in the line of this circle, reality is the projection of this circle to a straight 1D line.* We add one dimension and imagine that all energy is in a 2D reality, which is the surface of a sphere around O. The sphere is expanding at the speed c. *For an observer in the surface of this sphere, reality is the projection of this sphere to a flat 2D surface.* We add one last dimension and imagine that all energy is in a 3D reality, which is the 3D hypersurface of a 4D hypersphere around O. The hypersphere is expanding at the speed c. *For an observer in the hypersurface of this hypersphere, reality is the projection of this hypersphere to a flat 3D space.* We stop here and claim: The third scenario is the world that we live in. For each observer, the 4D hypersphere is projected to his proper 3D space. *The 3D hypersurface is absolute, but the proper 3D space of an observer is relative.*

In all three scenarios, the radius r divided by time is equal to c. This concept of time (Euclidean time) isn't egocentric, but universal, as it originates from an absolute point! We define a 4D vector "flow of time" $\boldsymbol{r}/c$, where $\boldsymbol{r}$ points from O to an object. The absolute value r/c of this vector is universal, but its 4D orientation is unique. For each object, time flows in a unique 4D direction related to its position. The 4D hypersphere is also projected to an observer's proper flow of time. So, all observed clocks are slow in his proper flow of time. *Euclidean time is absolute, but the proper flow of time of an observer is relative.*

$$\tau = r/c \qquad \textit{(Euclidean time)}. \tag{3}$$

Eq. (3) tells us that Euclidean time is only a subordinate quantity derived from covered distance. Time isn't fundamental to physics as already claimed by other authors [16]. Distance and speed are more significant than time. So, we suggest to choose new units for speed and time. c should be specified in its own new unit to be given. τ should be specified in "light seconds per this new unit". Be aware that these new units won't affect how clocks are running. So, all of our clocks will measure Euclidean time, too.

Mathematically, ES is an open 4D manifold with a Euclidean metric. We can describe ES either in four *absolute* 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 *relative*, symmetric Cartesian coordinates (d_1, d_2, d_3, d_4), where each d_i is *axial distance* from an origin. In our new concept "distance", each distance (r and d_i) is spatial and temporal distance in one. Distance isn't covered as a function of an independent time. **Only by covering distance is Euclidean time passing by.** Distances are measured in light seconds (Ls) by odometers. There is no need to calibrate these odometers as light seconds in ES are absolute.

An observer's reality is created by projecting ES to his proper 3D space and to his proper flow of time. ES is that master frame which is missing in SR and GR. Euclidean time is the proper time of all objects/observers, whereas Einstein time is the proper time of just one observer. In SR and GR, the proper time of an observed object deviates from the proper time of an observer. In ER, all objects/observers share the same time and the same 3D hypersurface, but each object/observer has a proper flow of time and a proper 3D space.

Hyperspherical coordinates are good for grasping the big picture that physics tries to describe in cosmology. We claim that a huge amount of energy was injected into ES at some point that we take as its origin O. Right here our first postulate comes into play: In ES, all energy is moving radially away from this origin at the speed of light. *That is, we live in the 3D hypersurface of an expanding 4D hypersphere.* Hyperspherical coordinates have the great benefit of reducing all that is ever happening to one formula: All energy is covering radial distance r which, divided by Euclidean time τ, is equal to the speed of light c. So, this formula is the Theory of Everything (TOE), but in hyperspherical coordinates.

$$r/\tau = c \qquad \textit{(Theory of Everything)}. \tag{4}$$

One may argue that Eq. (4) couldn't be a TOE as it wouldn't address all the dynamics in 3D space. We disagree. In hyperspherical coordinates, there is indeed no motion within the hypersurface because everything is moving radially at the same speed c. Yet, as we will demonstrate in Sect. 5.4, all the dynamics in 3D space is enabled by pure math (rotation and projection). So, Eq. (4) is the TOE in hyperspherical coordinates. We just follow a powerful strategy: Matching the symmetry simplifies physics!

Cartesian ES coordinates are good for projecting ES to an observer's reality. They are calculated from hyperspherical coordinates by

$$d_1 \;=\; r\,\cos\phi_1\;, \tag{5a}$$

$$d_2 \;=\; r\,\sin\phi_1\,\cos\phi_2\;, \tag{5b}$$

$$d_3 \;=\; r\,\sin\phi_1\,\sin\phi_2\,\cos\phi_3 \tag{5c}$$

$$d_4 \;=\; r\,\sin\phi_1\,\sin\phi_2\,\sin\phi_3\;. \tag{5d}$$

In our ES diagrams, we often choose Cartesian coordinates in which an object starts moving from some origin P other than O. Because of the ES symmetry, we are free to label all four axes. We always assume that the axis d_4 coincides with an object's proper flow of time $\boldsymbol{r}/c$. *That is, we take Euclidean time as the fourth coordinate of all objects.* Below our ES diagrams, we project ES to an observer's proper 3D space. Here we are free to label the axis that we project to. We always assume: Two objects that move relative to each other will do so only in the axes d_1 and d_4. So, our Cartesian ES diagrams display d_1 and d_4. Our 3D projections display only d_1. Keep in mind that d_1 stands for d_1, d_2, d_3.

The projections to an observer's proper 3D space and to his proper flow of time are orthogonal: $(d_1, d_2, d_3, d_4) \rightarrow (d_1, d_2, d_3)$ and $(d_1, d_2, d_3, d_4) \rightarrow (d_4)$. Figure 1 tells us that d_1, d_2, d_3 is the same 3D space as x_1, x_2, x_3, while d_4 is equal to $c\tau$ (and not to ct). The 4D velocity $\boldsymbol{u}$ of an object in Cartesian ES coordinates splits up into four components $u_i = \mathrm{d}d_i/\mathrm{d}\tau$ with

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

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. The rockets move relative to each other in 3D space at the constant speed $v_{3\mathrm{D}}$ (Figure 2 bottom). As just explained, this 3D motion is in d_1 and 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.

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 $L_{i,\mathrm{R}}$ (or $L_{i,\mathrm{B}}$) 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.

$$\sin^2\varphi \,+\, \cos^2\varphi \;=\; (L_{\mathrm{b,R}}/L_{\mathrm{b,B}})^2 \,+\, (v_{3\mathrm{D}}/c)^2 \;=\; 1 \tag{7}$$

$$L_{\mathrm{b,R}} \;=\; \gamma^{-1}\,L_{\mathrm{b,B}} \qquad \textit{(Length contraction)}, \tag{8}$$

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

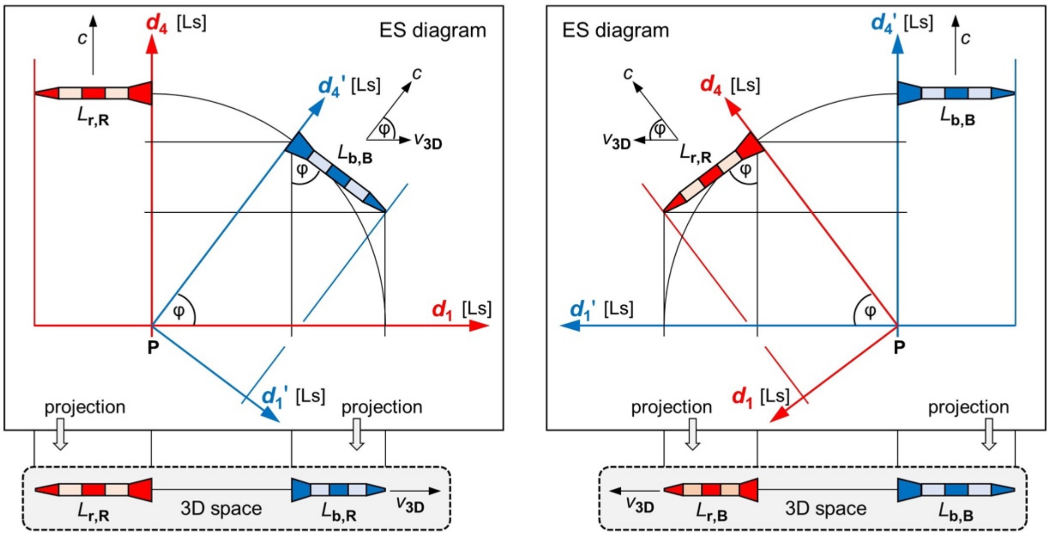

Figure 2. ES diagrams and 3D projections for two identical rockets. All axes are in Ls (light seconds). **Top left and top right:** In the ES diagrams, both rockets are moving at the speed c, but in different directions. **Bottom left:** Projection to the 3D space of R. The relative speed is v_{3D}.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

$$\sin^2\varphi + \cos^2\varphi = (d_{4,B}/d'_{4,B})^2 + (v_{3D}/c)^2 = 1 , \tag{9}$$

$$d_{4,B} = \gamma^{-1}\, d'_{4,B} , \tag{10}$$

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

$$t_R = \gamma\, t_B \qquad \textit{(Einstein time dilation)}, \tag{11}$$

where t_R (or t_B) is the distance that R (or else B) has moved in the Einstein time t of R. Eq. (11) tells us that clocks inside b are slow with respect to R not in the variable t' of B, but in the variable t of R. This variable relates to d_4 in Figure 1 center.

We just derived length contraction and Einstein time dilation by applying the master frame ES provided by ER. At first, we thought that Einstein time is just some inconvenient concept, and everything else will be alright. But when we realized that ER solves mysteries which SR and GR haven't solved in 100+ years (see Sect. 5), we concluded that the issue in Einstein time is real. It affects all of physics including SR. However, the Lorentz factor γ and thus length contraction and time dilation are recovered in ER. This is why the issue doesn't affect the predictions made by SR. In SR, time dilation is just stored in the wrong variables. In the variable τ of Euclidean time, there is no time dilation because all observers experience the same absolute time at once ($\tau_R = \tau_B$).

It is important to realize that the Lorentz factor γ in Eqs. (8) and (11) is the same as in SR. Despite the Euclidean metric in ER, the Lorentz factor γ is recovered. Actually, this is no surprise because Hermann Weyl already showed that the generators of the Lorentz group are 4D rotations [17]. Montanus [8] and Gersten [11] demonstrated that the Lorentz transformation is recovered in ER. So, we won't repeat their proof here. *Predictions made by SR are correct because the Lorentz transformation is equivalent to a 4D rotation.*

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 Eq. (6), the speed u_1 of b must

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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.

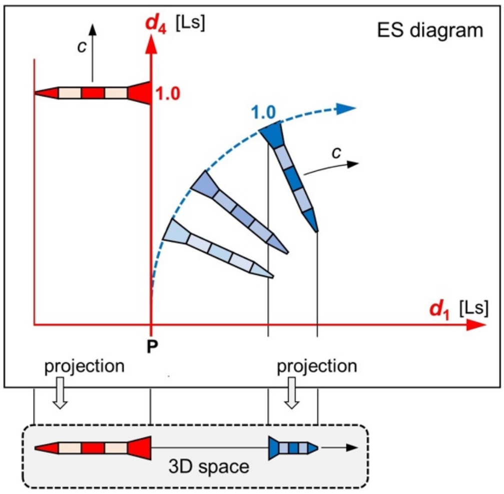

Figure 3. ES diagram and 3D projection for two identical rockets. **Top:** In the ES diagram, the red rocket moves in the steady axis d_4. The blue rocket accelerates in the axis d_1. Its speed u_1 increases at the expense of its speed u_4. **Bottom:** Projection to the 3D space of R. The red rocket 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. Eq. (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, and vice versa. We conclude: If an object accelerates in an observer's proper 3D space, its clocks decelerate with respect to his clocks. Be aware that this effect is observed only in Einstein time where an observer projects an object's proper flow of time to his proper flow of time.

Understanding gravitation is still one of the biggest challenges of physics. Gravitational waves support the idea of GR that gravitation is a property of spacetime. Yet they might be predicted by ER, too. The measurement of gravitational waves [18] was a great achievement of physics, but even they can't make GR compatible with quantum mechanics. Physics, especially particle physics, is still considering gravitation a force that has not yet been unified with the other forces of physics. *We claim that curved trajectories in Cartesian ES coordinates replace "curved spacetime" in GR.* Eq. (6) is the key equation which relates a motion in d_4 to a motion in d_1. To support our claim, we now calculate time dilation in the gravitational field of Earth. Clock A is very far away from Earth and is emitting time signals at infinitesimally short intervals. Receiver B with the mass m starts at the position of A, approaches Earth, and detects these time signals. The kinetic energy of B is

$$\tfrac{1}{2}\, m\, u_{1,\mathrm{B}}^2 \;=\; G\, M\, m/r \tag{12}$$

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 Eq. (6), we get

$$u_{1,\mathrm{B}}^2 + u_{4,\mathrm{B}}^2 \;=\; 2\, G\, M/r + u_{4,\mathrm{B}}^2 \;=\; c^2 \;, \tag{13}$$

$$u_{4,\mathrm{B}}^2/c^2 \;=\; 1 - 2\, G\, M/(rc^2) \;, \tag{14}$$

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' because of the accelerated motion of B), we get

$$\mathrm{d}t_\mathrm{B} \;=\; (1 - 2\, G\, M/(rc^2))^{0.5}\, \mathrm{d}t_\mathrm{A} \;, \tag{15}$$

$$dt_A \;=\; \gamma_{grav}\, dt_B \qquad \textit{(Gravitational time dilation)}, \tag{16}$$

where dt_A (or dt_B) is the distance that A (or else B) has moved in the Einstein time t of A in between consecutive time signals. There is gravitational time dilation only in Einstein time. The dilation factor $\gamma_{grav} = (1 - 2GM/(rc^2))^{-0.5}$ is the same as in GR [2]. It has the same form as γ if we set $2GM/r$ equal to v_{3D}^2. Be aware that Eq. (16) is independent of $u_{1,B}$. So, Eq. (16) applies whether or not B is still moving relative to 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: In billiards, a cue ball is hit to collide with the red ball. In ES, cue ball and red ball move at the speed c. We assume that the red ball moves in some axis d_4. As the cue ball covers spatial distance to the red ball, its speed in d_4 must be slower than c. How can the balls collide if their d_4 values never match? Problem 3: A mirror is passing 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 rocket moves in some axis d_4. How can the observer detect the reflection?

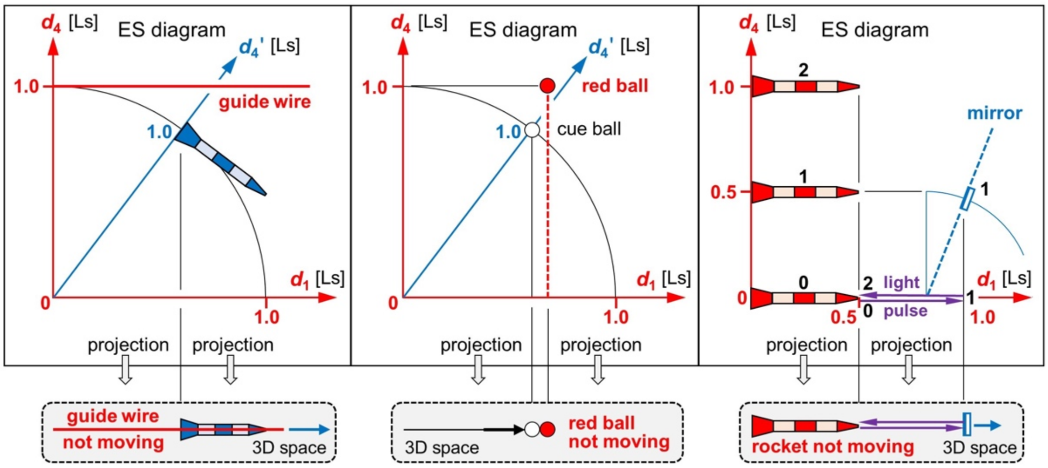

Figure 4. Graphical solutions to three geometric paradoxes. **Left:** A rocket moves along a guide wire. In 3D space, the guide wire remains within the rocket. **Center:** A cue ball is hit to collide with the red ball. In 3D space, the cue ball collides with the red ball. **Right:** An observer in a 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.

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 to 3D space orthogonally (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 cue ball collides with the red ball; the light pulse is reflected back to the observer. Other ER models [8–14] run into paradoxes as they don't project ES to an observer's proper 3D space.

5. Solving 15 Fundamental Mysteries of Physics

In this section, we demonstrate that ER outperforms SR and GR in the understanding of time, time's arrow, mc^2, cosmology, quantum mechanics, and particle physics.

5.1. Solving the Mystery of Time

Euclidean time is radial distance r from an origin O (Big Bang, see Sect. 5.4) divided by c. *The natural concept of time originates from the Big Bang rather than from an observer.* Time can't be observed as it disappears because of length contraction. Since time flows in countless directions, the metaphor of time being one 1D line is limited. 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 Big Bang: The 4D vectors "flow of time" can't be reversed because radial momentum provided by the Big Bang drives all energy irreversibly away from the origin O.

5.3. Solving the Mystery of mc^2

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

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

where $E_{\mathrm{kin,3D}}$ is an object's 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 of light. ER gives us this missing clue and is thus superior to SR: *mc^2 is the kinetic energy of moving through the fourth dimension.* The c^2 in Eq. (17) is strong evidence that everything is moving through ES at the speed c, while it is at rest in its proper 3D space. There is also

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

where p and p_{3D} are the momenta of an object in ES and in 3D space. Dividing Eq. (18) by c^2 gives us the vector addition of an object's momentum in its proper 3D space *and its momentum mc of moving through the fourth dimension.*

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 mostly in the dark. As shown in Sect. 4, ER discloses that these effects stem from a rotation and a projection.

5.5. Solving the Mystery of Gravitational Time Dilation

Eq. (16) 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 the field. The object's curved trajectory in Cartesian ES coordinates is projected to his proper 3D space (here the object accelerates) and to his proper flow of time (here the object decelerates). Curved trajectories in Cartesian ES coordinates replace "curved spacetime" in GR.

5.6. Solving the Mystery of the Cosmic Microwave Background

Now we are ready for a new model of cosmology, which is 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 today's model of cosmology, it makes no sense to ask *where* the Big Bang occurred: Because space inflated from a singularity, the Big Bang occurred everywhere. In ES, it is indeed possible *to localize the Big Bang* at what we take as its origin O. The Big Bang injected a huge amount of energy into ES all at once. Ever since has all this energy been moving radially away from O at the speed c.

During the initial stage after the Big Bang, there was a huge amount of concentrated energy in ES. In the projection to any proper 3D space, this energy created a very hot and dense plasma. While the plasma was expanding, it cooled down. During the recombination of plasma particles, electromagnetic radiation was emitted that we observe as cosmic microwave background (CMB) [19]. At a temperature of roughly 3,000 K, hydrogen atoms formed. According to today's model of

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cosmology, this stage was reached approximately 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 if the universe has always been expanding at the constant speed c.

Yet why is the CMB so isotropic? Here is our answer: The CMB is so isotropic because it is "swinging" equally from ES into all three dimensions of my 3D space (Figure 5). To grasp the process of swinging, we mentally continue the rotation of the blue rocket in Figure 2 top left until it is pointing vertically down. We then mentally replace this blue rocket with a photon and finally look at its projection to my 3D space. Here is what we learn from this thought experiment: In each photon, I actually observe energy from ES whose 4D motion swings "completely" (by an angle of $90°$) into my 3D space.

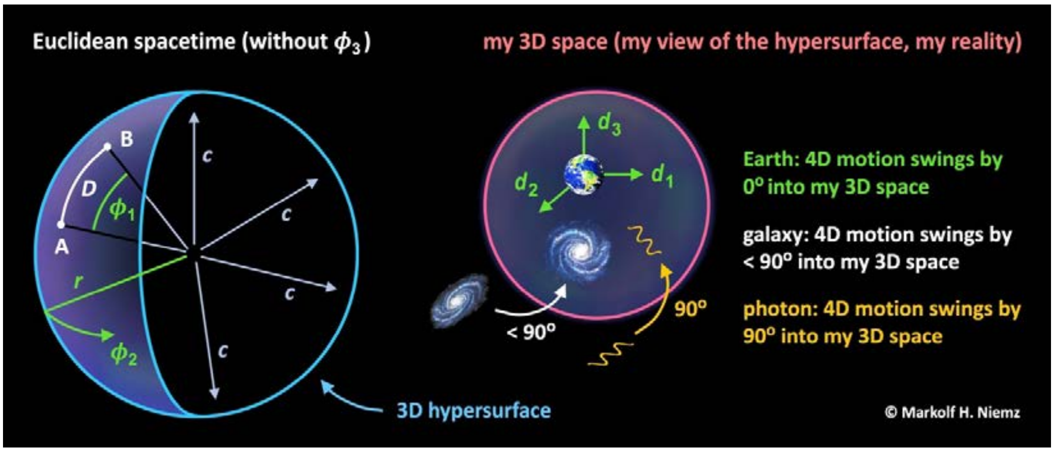

Figure 5. Model of cosmology based on ER (not to scale). Artwork illustrating how a 3D hypersurface is expanding in ES. **Left:** Non-observable ES in hyperspherical coordinates $(\phi_1, \phi_2, \phi_3, r)$. The angle ϕ_3 can't be displayed here. Hubble's law is derived from the geometry of the hypersurface. **Right:** My 3D space in Cartesian coordinates (d_1, d_2, d_3), which is my view of the hypersurface and my reality. The axis d_4 (related to time) disappears because of length contraction

Our eyes aren't made for *perceiving* all four dimensions of ES. Yet we can *conceive* of them with our brain by employing our trick: rotating that blue rocket in Figure 2 top left and looking at its projection to 3D space. This trick tells us that the process of swinging covers both operations: "Swinging" is one word for the combined action of rotating and projecting. In my 3D space, I observe the final result of this combined action.

We learned that a photon is energy whose 4D motion swings completely into my 3D space ($v_{3D} = c$). Matter is energy whose 4D motion swings "partly" (by an angle of $< 90°$) into my 3D space ($v_{3D} < c$). The swing angle of Earth is $0°$ as it doesn't move relative to myself ($v_{3D} = 0$). *We would be mistaken if we thought that the pure radial motion of energy in hyperspherical coordinates would prevent objects in my 3D space from moving towards each other.* Reality is a projection of ES: Swinging enables all the dynamics in 3D space!

Photons are moving in my view of the hypersurface at the speed c, while the entire hypersurface is expanding at the speed c. One may ask: Doesn't a photon then exceed the speed c? No, it doesn't. Speeds in my view of the hypersurface must not be added to the speed of the hypersurface itself. Each photon that I observe is energy from ES whose 4D motion swings completely into my 3D space. That is to say: In the speed c of each photon, I already see the speed c of the hypersurface.

5.7. Solving the Mystery of Hubble's Law

The 3D speed v_{3D} at which a galaxy A is moving away from a galaxy B or from Earth relates to their distance D as c relates to the radius r of the hypersurface (Figure 5).

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

where $H_0 = c/r$ is the Hubble constant, c is in km/s, and r is in Mpc. There it is! Eq. (19) is Hubble's law [20]: *The farther a galaxy, the faster it is moving away from Earth.* We derived it from the geometry of an expanding hypersurface. Because of Eq. (3), there is $H_0 = 1/\tau$. So, it does make sense to speak of a "Hubble function" $H(\tau) = 1/\tau$. Be aware that we must be very careful with the popular metaphor of an inflating balloon. The 3D hypersurface shown in Figure 5 only looks like the surface of a 3D sphere because the angle ϕ_3 can't be displayed in such a 2D illustration.

5.8. Solving the Mystery of the Flat Universe

Because the entire hypersurface is expanding at the speed of light (Figure 5), the radial dimension disappears for any observer inside the hypersurface. Together with this dimension, the 4D curvature of the 3D hypersurface disappears as well. He observes a flat 3D universe. His situation compares to that of an ant: Since it observes just two dimensions of space, the 3D curvature of Earth's 2D surface disappears for the ant.

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 universe, and large-scale structures (inflated from quantum fluctuations). We showed that an expanding 3D hypersurface can explain the first two of these observations. It also explains the third observation if we only assume that there had been quantum fluctuations in energy in the early hypersurface. Ever since have the impacts of all these quantum fluctuations 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 calculations of calibrated distance ladder techniques (measurement of distance and redshift of celestial objects) using the *Hubble space telescope* [24]. By taking the ES geometry into account, we now explain why the values of H_0 obtained by these two teams don't even 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. Let us assume that 67.66 km/s/Mpc would be today's value of H_0. Here we simulate a supernova at a distance of $D = 400$ Mpc from Earth. It is moving at the 3D speed v_{3D} away from Earth. Eq. (19) gives us

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

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

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 it 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 will measure a too-high value z', and thus calculate a too-high value v'_{3D}, and thus calculate a too-high value H'_0. Figure 6 left shows the geometry of the supernova and Earth in hyperspherical coordinates. There is one circle called "past", where the supernova occurred, and a second circle called "present", where its light is observed on Earth. Today, this supernova has turned into a neutron star. Figure 6 top right shows the same geometry, but in Cartesian coordinates. Since everything is moving through ES at the speed c, Earth has moved the distance D in d_4 when the supernova's light arrives. Hence, team B is receiving data from a time $\tau' = 1/H'_0$ when there was a different radius r' and a different Hubble constant H'_0.

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$$1/H_0' \;=\; r'/c \;=\; (r-D)/c \;=\; 1/H_0 \;-\; D/c\ . \tag{22}$$

$$H_0' \;=\; 74.37\ \text{km/s/Mpc}\ . \tag{23}$$

Because of this higher value and of Eq. (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. So, because of Eq. (21) this is going to happen: Team B measures a redshift of $z' = 0.0992$, which is indeed higher than 0.0903. Because of this too-high value of z', team B will calculate $v_{3D}' = 29{,}748$ km/s from Eq. (21) and thus $H_0' =$ 74.37 km/s/Mpc from Eq. (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 Eq. (22) and of the ES geometry shown in Figure 6.

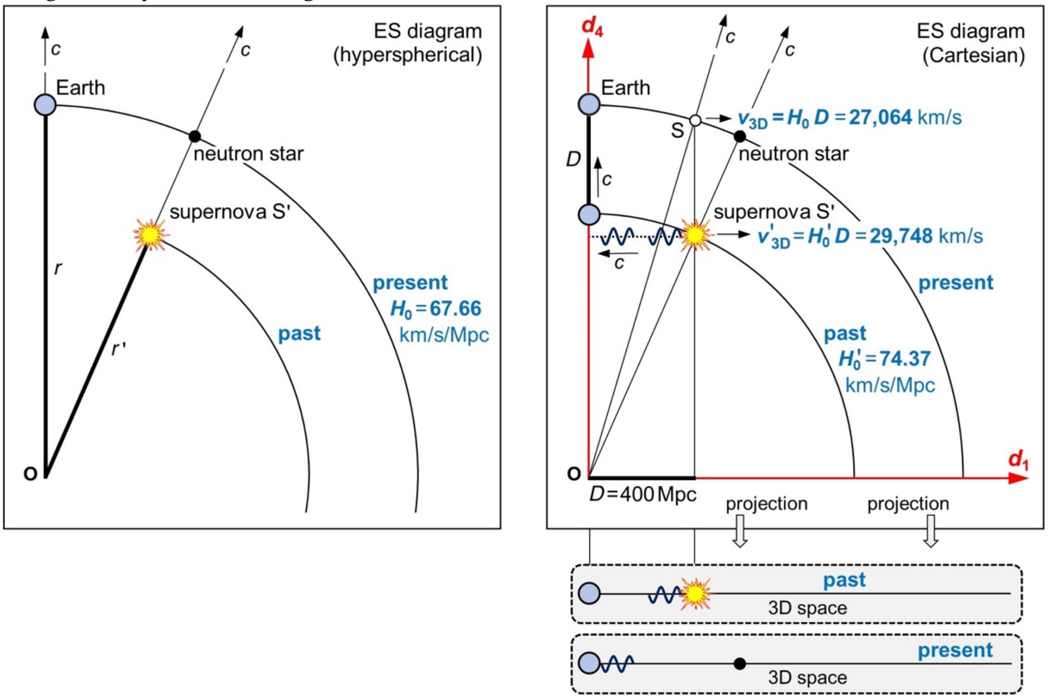

Figure 6. ES diagrams for team B's calculation of the Hubble constant. The location of the Big Bang serves as the origin O. **Left:** We assume that 67.66 km/s/Mpc would be today's value of the Hubble constant H_0 (present). A supernova S′ occurred in the past when the radius r' of the hypersurface was smaller than today's radius r. **Right:** Team B observes S′ and measures a distance of 400 Mpc. Since the occurrence of S′, Earth has also moved 400 Mpc, but in the axis d_4. Team B calculates a Hubble constant H_0' of the past (74.37 km/s/Mpc). A supernova S occurring today (same distance, small white circle) recedes slower (27,064 km/s) than a supernova S′ in the past (29,748 km/s)

For a shorter distance of $D = 400$ kpc, Eq. (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 Eq. (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: $H_0 =$

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$67 - 68$ km/s/Mpc. If the 3D hypersurface has been expanding uniformly at the speed c, the age of today's universe is equal to $1/H_0$. In this case, its age wouldn't be 13.8 billion years [25], but 14.5 billion years. The adjusted age would explain the observation that there are stars out there as old as 14.5 billion years [26].

As pointed out in Sect. 3, there is no motion within the hypersurface in hyperspherical coordinates. This is why we can't draw the path of the supernova's light in Figure 6 left. Only in Cartesian ES coordinates (Figure 6 top right) can we display the light's path horizontally as we already did in Figure 4 top right. In order to see an observer's reality, we have to project Cartesian ES coordinates to his proper 3D space (Figure 6 bottom right).

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 hypersurface is expanding in ES. *The hypersurface isn't expanding space, but energy that is actively receding from the origin O.*

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 Eq. (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 Eq. (21).

Our model gives a much simpler explanation for the deviations from Hubble's law: Because of Eq. (3), there is $H_0 = 1/\tau$. So, H_0 isn't a constant. H_0' from every past is higher than today's value. The older the considered 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 6 top right helps us understand these deviations: If a new supernova S occurred today at the same distance $D = 400$ Mpc as the mapped supernova S' in the past, then 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, the too-high redshifts are attributed to an accelerating expansion of space. Now that we know about the ES geometry, we can attribute different redshifts to data from different 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 (which is receding energy), but no accelerating expansion whatsoever. ***Expansion of space is a redundant concept.***

The term "dark energy" [30] was coined to come up with a cause for an accelerating expansion of space. Because there is no accelerating expansion of space, ***dark energy is a redundant concept, too.*** It has never been observed anyway. Radial momentum provided by the Big Bang drives all energy away from the origin O. So, the receding hypersurface is driven by itself rather than by dark energy.

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Table 1 summarizes huge differences in the meaning of the Big Bang, 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, the universe is all space, all time, and all energy. In our model, the universe is my view of a 3D hypersurface (of receding energy). In the Lambda-CDM model, spacetime is curved. In our model, curved trajectories in Cartesian ES coordinates relate to accelerations in an observer's proper 3D space and in his proper flow of time. While the Lambda-CDM model isn't compatible with quantum mechanics, our model is compatible.

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.
Universe is all space, all time, and all energy.	Universe is my view of a 3D hypersurface.
Neither space nor time are absolute.	3D hypersurface and time are absolute.
Space and time are relative.	3D space and flow of time are relative.
Space is inflating and expanding.	All energy is receding radially from O.
Space is driven by dark energy.	All energy is driven by radial momentum.
Spacetime is curved.	Trajectories 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 <u>third postulate:</u> 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 7 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 $v_{3D} \leq c$, 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.*

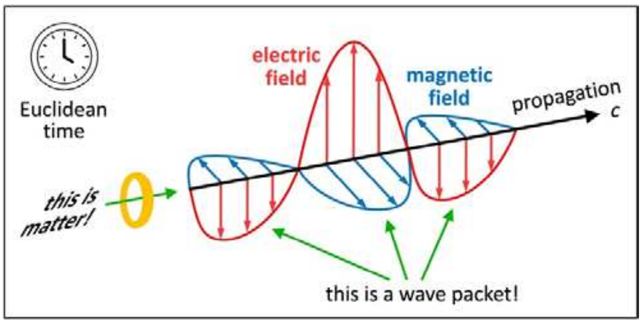

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Figure 7. Concept of wavematter. Artwork illustrating how one object can be deemed wave or matter. Wavematter comes in four orthogonal dimensions: propagation, electric field, magnetic field, and Euclidean time. Each wavematter deems itself matter 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. So, its own propagating and oscillating 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. 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. In today's physics, there is no reference frame moving at the speed c and thus no internal view of a photon.

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 8 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 8 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 8 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 8 bottom right). As the axis d_4' disappears because of length contraction, WM_3 also deems itself matter at rest (M_3).

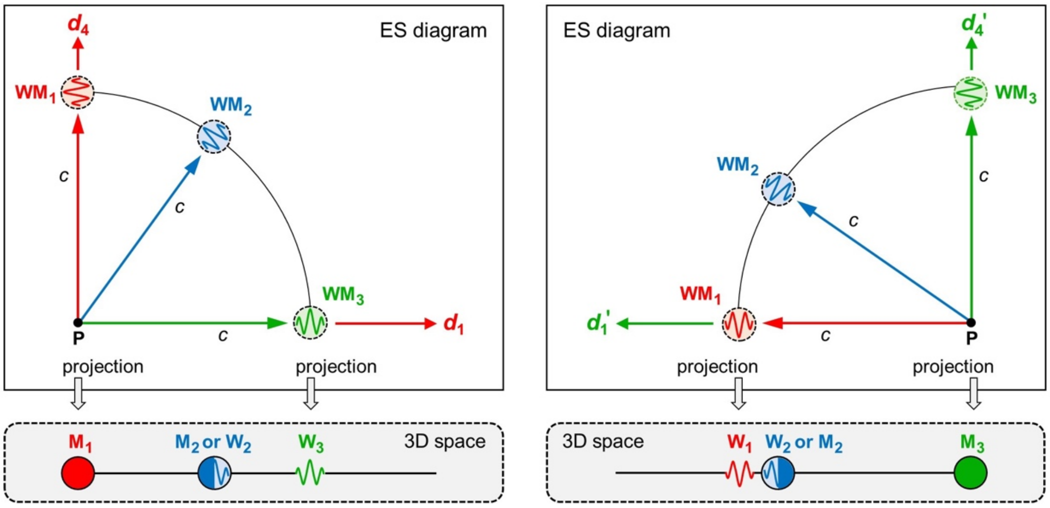

Figure 8. ES diagrams and 3D projections for three wavematters. **Top left:** ES in coordinates where WM_1 moves in d_4. **Top right:** ES in coordinates where WM_3 moves in d_4'. **Bottom left:** Projection to WM_1's 3D space. WM_1 deems itself matter at rest (M_1) and WM_3 wave (W_3). **Bottom right:** Projection to WM_3's 3D space. WM_3 deems itself matter at rest (M_3) and WM_1 wave (W_1)

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. As the rotation angle is $90°$, WM_3's 4D motion swings completely into WM_1's 3D space. So, WM_1 deems WM_3 wave (W_3), while WM_3 deems WM_1 wave (W_1). 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 deems WM_2 either matter (M_2) or wave (W_2).

The secret to understanding our new concepts "distance" and "wavematter" is all in Figure 8. Here we see how they go hand in hand: We claim the symmetry of all four Cartesian coordinates in

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ES and—on top of that—the symmetry of all objects in ES. *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 matter and waves 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 that pass through a double-slit and produce some pattern of interference on a screen. We already know that he observes wavematters from ES whose 4D motion swings 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 issue of non-locality. All we need to do is discuss quantum entanglement in ES. Figure 9 illustrates 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 these wavematters 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 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.

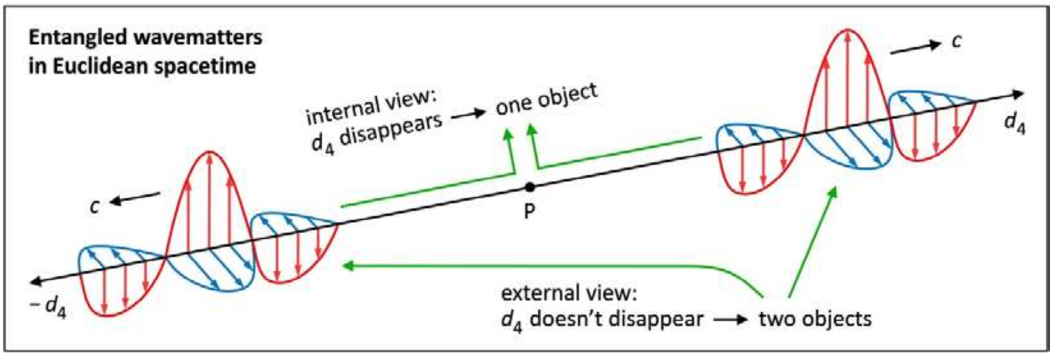

Figure 9. Quantum entanglement in ES. Artwork illustrating internal view and external view. For each displayed wavematter, the axis d_4 disappears because of length contraction. It deems its twin and itself one object (internal view). For a third wavematter that is moving in a direction other than d_4, 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 9, the axis d_4 disappears because of length contraction at the speed c. That is to say: In the projection to its own 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 by an angle of $90°$ into an observer's proper 3D space—and this energy speeds off all 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 for *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. The baryon asymmetry is due to our claim that wavematter deems itself matter. 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.

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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. We also conclude that ER is compatible with quantum mechanics.

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: We live in the 3D hypersurface of an expanding 4D hypersphere—its radius, divided by the speed of light, is time! Just 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. For quantum leaps in understanding, we must question existing concepts. It certainly was to our advantage that we weren't dazzled by the success of SR and GR. Einstein sacrificed absolute space and time. We sacrifice the absoluteness of waves and matter, but we restore absolute time and pair it with an absolute hypersurface. 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: *beauty and symmetry*. 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".**

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. Here is our advice: Think of a problem in physics and try to solve it in ER. We predict that ER is covering gravitational waves, too. You are welcome to join us in this paradigm shift. Hopefully, it will improve our understanding of physics.

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 and contributed the concepts "distance" and "wavematter", which 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 that ES diagrams must be rotationally symmetric and solved the mystery of competing Hubble constants.

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