Euclidean Relativity Solves 15 Mysteries of Physics   2

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Special and general relativity (SR/GR) describe nature *subjectively.* Mathematically, they are correct.   6
Here I show: (1) Physically, SR/GR have an issue. Both theories describe nature from the perspective   7
of just one observer each (one group of observers, to be exact). After a transformation, there is again   8
just one active perspective. Because of this constraint, there is no holistic view of nature. The issue   9
manifests itself in the fact that SR/GR have not solved several mysteries, such as the Hubble tension,   10
dark energy, and non-locality. Still, SR/GR work well for each observer because the Lorentz factor   11
and gravitational time dilation are correct. **(2)** Euclidean relativity (ER) describes nature *objectively.*   12
Any (!) object's proper space d_1, d_2, d_3 and its proper time τ span "natural spacetime", which is 4D   13
Euclidean space (ES) if we interpret $c\tau$ as d_4. All energy moves through ES at the speed of light c.   14
Each observer's reality is created by projecting ES orthogonally to his proper space and to his proper   15
time. These two concepts are reassembled in SR/GR to a non-Euclidean spacetime. Since information   16
is lost in each projection, the performance of SR/GR is limited. However, the SO(4) symmetry of ES   17
is not compatible with waves. This is fine because ER tells us that wave and particle are subjective   18
concepts: *What I deem wave, deems itself particle at rest.* We must distinguish between the master reality   19
ES (without waves) and an observer's reality (with waves). **I conclude:** A holistic view of nature is   20
a necessary requirement for solving the Hubble tension, dark energy, and non-locality.   21

Keywords: spacetime; cosmology; Hubble constant; Hubble diagram; quantum mechanics   22

Important Remarks   23

There are two options of how to describe nature: from the perspective of one observer   24
or from the perspective of any (!) object. Special and general relativity (SR/GR) [1,2] follow   25
the first way and describe nature *subjectively.* SR/GR are mathematically correct, but they   26
have a physical issue: SR/GR do not enable a holistic view of nature because they describe   27
nature from the perspective of just one observer each (one group of observers, to be exact).   28
Euclidean relativity (ER) follows the second way and describes nature *objectively.* It takes   29
a conceptual leap (paradigm shift) to accept ER, so be prepared.   30

Six pieces of advice: (1) *Do not take SR/GR as the ultimate truth.* Some reviewers made   31
a systematic error when they evaluated ER with the concepts of SR/GR. ER is different. In   32
ER, all energy moves at the speed of light c. (2) *Be patient and fair.* I cannot address all of   33
physics in one paper. SR/GR have been tested for 100+ years. ER deserves the same chance.   34
(3) *Do not reject ER on a knee-jerk reaction.* What is wrong with describing nature objectively   35
rather than subjectively? (4) *Do not be prejudiced against a theory that solves many mysteries.*   36
New concepts often do so. (5) *Appreciate illustrations.* Geometric derivations are as good as   37
equations. (6) *Consider that you may be biased.* Some concepts of physics are obsolete in ER.   38
If you are an expert in one of these concepts, you may feel offended.   39

To sum it all up: Predictions made by SR/GR are correct, but ER penetrates to a deeper   40
level. I apologize for having prepared several preprint versions. It was difficult to figure   41
out why SR/GR work so well for each observer despite an issue. Sect. 2 is about this issue.   42
In Sect. 3, I formulate the basic physics of ER. In Sect. 4, I recover the Lorentz factor and   43
gravitational time dilation. In Sect. 5, ER solves 15 mysteries of physics.   44

1. Introduction

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

Two postulates of ER: (1) All energy moves through 4D Euclidean space (ES) at the speed of light c. (2) The laws of physics have the same form in each "observer's reality", which is created by projecting ES orthogonally to his proper space and to his proper time. My first postulate is stronger than the second postulate of SR: c is absolute and universal. My second postulate is restricted to each observer's reality rather than to inertial frames. ER also comes with a generalized concept of energy: All energy in ES is made up of quanta that may appear as wave packets and particles for different observers.

In 1969, Newburgh and Phipps introduced ER [8]. Montanus distinguished absolute from relative Euclidean spacetime (AEST, REST) [9]. AEST is ES. REST is ES in an object's "ES diagram" (see Sect. 3). Montanus also verified gravitational lensing and the perihelion precession of elliptical orbits in ES [10,11]. He even tried to formulate electrodynamics in ES [10,11], but he overlooked that the SO(4) symmetry of ES is not compatible with waves. Almeida studied geodesics in ES [12]. Gersten showed that the Lorentz transformation is an SO(4) rotation in a "mixed space" (see Sect. 3) [13]. van Linden reviews ER models [14]. Physicists still reject ER because: (1) They expect waves to be covered. (2) Dark energy and non-locality make cosmology and QM work. (3) ER faces several paradoxes if not applied properly (see Sect. 4). *This paper marks a turning point:* I disclose a physical issue in SR/GR; I explain why there are no waves in ER; I avoid paradoxes by projecting ES.

It is instructive to contrast Newton's physics, Einstein's physics, and ER. In Newton's physics, all energy moves through 3D Euclidean space as a function of independent time. The speed of matter is $v_{3D} \ll c$. In Einstein's physics, all energy moves through 4D non-Euclidean spacetime. The speed of matter is $v_{3D} < c$. In ER, all energy moves through 4D Euclidean space. The 4D speed of all energy is $u_{4D} = c$. Newton's physics [15] reformed philosophy. Chances are that ER will reform physics and philosophy.

2. Disclosing an Issue in Special and General Relativity

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

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

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

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

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

where K' moves relative to K in x_1 at the constant speed v_{3D}, while $\gamma = (1 - v_{3D}^2/c^2)^{-0.5}$ is the Lorentz factor. *Mathematically*, Eqs. (1) and (2a–b) are correct for an observer R in K. There are covariant equations for an observer B in K'.

Physically, SR and also GR have an issue. Both theories describe nature from the perspective of just one observer each (one group of observers, to be exact). In SR, the group consists of observers who do not move relative to each other. In GR, the group consists of

observers who share the same gravitational field. Because of this constraint ("just one ob- 98
server each"), there is no holistic view of nature. In particular, two groups will not always 99
agree on what is past and what is future. Physicists have been playing down the constraint 100
by surrendering the concept of simultaneity. I show that the constraint is a physical issue. 101
By replacing SR/GR with ER, we will solve 15 mysteries of physics. However, I do not disprove 102
SR/GR. Both theories do their job very well in an observer's reality. 103

The issue in SR/GR is very similar to the issue in the geocentric model: In either case, 104
there is no holistic view, but just one *active* perspective. In the Middle Ages, it was natural 105
to believe that all celestial bodies would revolve around Earth. Only the astronomers won- 106
dered about the retrograde loops of planets and claimed: Earth revolves around the sun. 107
In modern times, engineers have improved the precision of rulers and clocks. Eventually, 108
it was natural to believe that it would be fine to describe nature as accurately as possible, 109
but from just one *active* perspective. The human brain is very powerful, but unfortunately 110
it often deems itself the center/measure of everything in the universe. 111

The analogy is strong: (1) It holds despite the covariance of SR/GR. After a transfor- 112
mation (or else after replacing the center Earth), there is again just one *active* perspective. 113
(2) SR/GR miss the big picture just like the geocentric model. Retrograde loops are obso- 114
lete, but only in the holistic view of the heliocentric model. Dark energy and non-locality 115
are obsolete, but only in the holistic view of ER. (3) In the Middle Ages, it was not accepted 116
to challenge the geocentric model. Today, most editors do not accept papers that challenge 117
SR/GR. *Have physicists not learned from history? Does history repeat itself?* 118

3. Basic Physics of Euclidean Relativity 119

The indefinite distance function in SR [1] is usually written as 120

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$$c^2\, \mathrm{d}\tau^2 \;=\; c^2\, \mathrm{d}t^2 \;-\; \mathrm{d}x_1^2 \;-\; \mathrm{d}x_2^2 \;-\; \mathrm{d}x_3^2 \;, \tag{3}$$ 122

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where $\mathrm{d}\tau$ is an infinitesimal distance in proper time τ, while $\mathrm{d}t$ and $\mathrm{d}x_i$ are infinitesimal 124
distances in "coordinate spacetime" x_1, x_2, x_3, t. This concept is *construed* because all four 125
coordinates are "extrinsic concepts" (concepts that are not immanent in rulers and clocks). 126
An observer defines them from his proper coordinates. We rearrange Eq. (3) and get 127

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$$c^2\, \mathrm{d}t^2 \;=\; \mathrm{d}d_1^2 \;+\; \mathrm{d}d_2^2 \;+\; \mathrm{d}d_3^2 \;+\; \mathrm{d}d_4^2 \;, \tag{4}$$ 129

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where $\mathrm{d}d_i = \mathrm{d}x_i$ $(i = 1, 2, 3)$ and $\mathrm{d}d_4 = c\, \mathrm{d}\tau$ are infinitesimal distances in ES. In Eq. (4), 131
the roles of t and τ have switched: The fourth coordinate in ER is an object's proper time 132
τ (what any clock measures), and t is the new invariant "cosmic time". I keep the symbol 133
t to point out that Eqs. (3) and (4) are equivalent. I use the indices "1, 2, 3, 4" rather than 134
"0, 1, 2, 3" to point out the full symmetry in ES. In ER, any object's proper space d_1, d_2, d_3 135
and its proper time τ span "natural spacetime", which is ES if we interpret $c\tau$ as d_4. This 136
concept is *natural* because all four coordinates are "intrinsic concepts" (concepts that are 137
immanent in rulers and clocks). We must not confuse the switch with the "Wick rotation" 138
[16], which just replaces t with it, but keeps τ as the invariant. 139

We are free to label the four axes of ES for each object. We always take d_4 as that axis 140
in which the object moves at the speed c. My "ES diagrams" illustrate ES from an object's 141
perspective. In these diagrams, the vertical axis is always d_4. An object keeps moving in 142
d_4 during its lifetime. An "object's reality" is created by projecting ES orthogonally to its 143
proper space d_1, d_2, d_3 and to its proper time $\tau = d_4/c$. For any two objects, d_4 and d_4' 144
(proper time τ and τ') may label different 4D directions. We specify 145

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$$\tau \;=\; d_4/c \;, \tag{5}$$ 147

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$$\boldsymbol{\tau} \;=\; d_4\, \boldsymbol{u}/c^2 \;, \tag{6}$$ 149

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where $\boldsymbol{\tau}$ is the 4D vector "proper flow of time" of an object and $\boldsymbol{u}$ is its 4D velocity. The 151
four components of $\boldsymbol{u}$ are $u_i = \mathrm{d}d_i/\mathrm{d}t$. Thus, Eq. (4) matches my first postulate 152

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$$u_1^2 + u_2^2 + u_3^2 + u_4^2 = c^2 \ . \tag{7}$$ 154
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My second postulate reformulates the principle of relativity. It also defines that each 156
"observer's reality" is created by projecting ES orthogonally to his proper space and to his 157
proper time. These two concepts are set equal to coordinate space and coordinate time in 158
SR (or parameterized in GR) and reassembled to a non-Euclidean spacetime. It may sound 159
tricky, but it just reflects that spacetime in SR/GR is customized to observers. Because of 160
two unequal projections, there is no smooth transition from ER to SR/GR, and vice versa. 161
We do not integrate the differentials in Eq. (3). We take an object's $d_1(t), d_2(t), d_3(t), \tau(t)$ 162
for granted rather than an observer's $x_1(\tau), x_2(\tau), x_3(\tau), t(\tau)$. 163

ES is the origin of each observer's reality. This is why I call ES the "master reality". 164
An observer's reality is unique because the two orthogonal projections depend on his po- 165
sition in ES. In SR/GR, spacetime is relative. In ER, natural spacetime is absolute, but the 166
ES diagrams and the two projections to an observer's reality are relative. However, the 167
SO(4) symmetry of ES is not compatible with waves. This is fine because ER tells us that 168
wave and particle are subjective concepts: What I deem wave, deems itself particle at rest 169
(see Sect. 5.12). We must distinguish between the master reality ES described by ER (with- 170
out waves) and an observer's reality described by SR/GR (with waves). 171

It is instructive to contrast coordinate time t, proper time τ, and cosmic time t. Co- 172
ordinate time t is an extrinsic measure of time: It is equal to $\tau = |\boldsymbol{\tau}|$ for the observer only. 173
Proper time τ is an intrinsic measure of time: It is independent of observers. Cosmic time 174
t is invariant and thus absolute: It is the total distance covered in ES (length of a geodesic) 175
divided by c. By taking τ as the fourth coordinate and the parameter t as absolute time, 176
it is possible for all observers to agree on what is past and what is future. However, time 177
is just a subordinate quantity in ER: Only by covering distance is time passing by. Thus, I 178
suggest to define new units for distance and speed and to measure time in these new units. 179
In some diagrams, I project ES to an "observer's 3D space" (his proper space). We are free 180
to label the axis of motion in his 3D space. We often take d_1 as this axis. 181

Let us compare SR with ER. We consider two identical clocks "r" (red clock) and "b" 182
(blue clock). In SR, "r" is at rest: It moves only in the axis ct at $x_1 = 0$. Clock "b" starts at 183
$x_1 = 0$, but it moves in the axis x_1 at the constant speed of $v_{3\mathrm{D}} = 0.6\,c$. Fig. 1 left shows 184
that instant when either clock moved 1.0 s in the coordinate time of "r". Clock "b" moved 185
0.6 Ls (light seconds) in x_1 and 0.8 Ls in ct' (time dilation). Thus, "b" displays "0.8". ER 186
is different: Fig. 1 right shows that instant when either clock moved 1.0 s in its proper time. 187
Both clocks display "1.0". Clock "b" moved 0.6 Ls in d_1 and 0.8 Ls in d_4. 188

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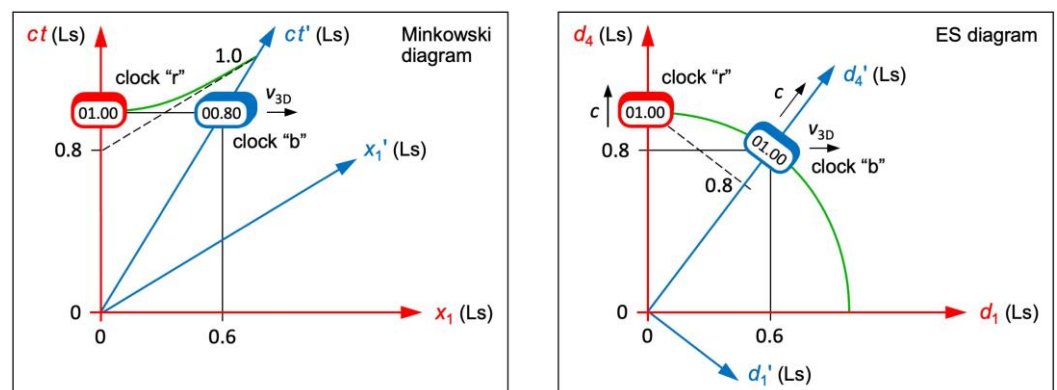
Figure 1. Minkowski diagram and ES diagram for two clocks "r" (red) and "b" (blue). **Left:** In SR, 190
"b" is slow with respect to "r" in t'. Coordinate time is relative ("b" is not at the same positions in 191
ct and ct'). **Right:** In ER, "b" is slow with respect to "r" in d_4. Cosmic time is absolute ("r" is in d_4 192
at the same position as "b" in d_4'). ER describes nature objectively. Just rotate the graph to see it! 193

Now watch out as this paragraph demystifies time dilation: Let observer R be with clock "r". Let observer B be with clock "b". In SR, t belongs to R and t' belongs to B. Observer R *calculates* (Lorentz transformation) that clock "b" displays $t' = 0.8$ s. Thus, "b" is slow with respect to "r" in t'. Time dilation in SR thus occurs in t', which belongs to B. In ER, d_4 belongs to R and d_4' belongs to B. Observer R *measures* (in his unprimed coordinate d_4) that clock "b" is at the position of $d_4 = 0.8$ Ls. Thus, "b" is slow with respect to "r" in d_4. Time dilation in ER thus occurs in d_4, which belongs to R. *In both SR and ER, "b" is slow with respect to "r"*. Coordinate time t or t' are construed coordinates, whereas proper time τ or τ' (d_4 or d_4') are natural/measurable quantities.

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

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

4. Geometric Effects in 4D Euclidean Space

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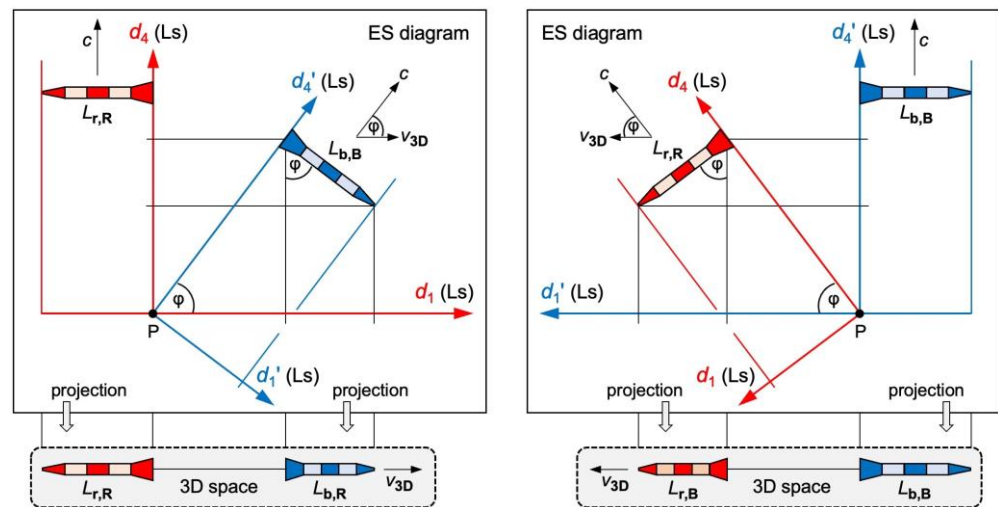
Figure 2. ES diagrams and 3D projections for two rockets "r" (red) and "b" (blue). All axes are in Ls (light seconds). **Top left and top right:** Both rockets move at the speed c, but in different directions. **Bottom left:** Projection to the 3D space of observer R. Rocket "b" recedes from "r" at the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

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

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

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

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

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

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

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

where $d_{4,B}$ (or $d'_{4,B}$) is the distance that B moved in d_4 (or else d'_4). With $d'_{4,B} = d_{4,R}$ (R and B cover the same distance in ES, but in different directions), we calculate

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

where $d_{4,R}$ is the distance that R moved in d_4. Eqs. (9) and (12) tell us: SR works so well because γ is recovered when projecting ES to d_1 and to d_4. This is not a surprise. Weyl showed that the Lorentz group is generated by 4D rotations [17].

To understand how an acceleration manifests itself in ES, we return to our two clocks "r" and "b". We assume that "r" and Earth move in the axis d_4 of "r" at the speed c and that "b" accelerates in the axis d_1 of "r" towards Earth (Fig. 3). Because of Eq. (7), the speed $u_{1,b}$ of "b" in d_1 increases at the expense of its speed $u_{4,b}$ in d_4.
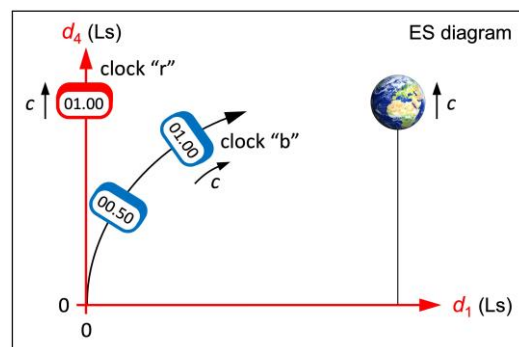
Figure 3. ES diagram for two clocks "r" (red) and "b" (blue). Clock "r" and Earth move in the axis d_4 of "r" at the speed c. Clock "b" accelerates in the axis d_1 of "r" towards Earth.

Gravitational waves [18] support the idea of GR that gravitation would be a feature of spacetime. However, particle physics is still considering gravitation a force, which has not yet been unified with the other forces of physics. I claim that curved geodesics in ES replace curved spacetime in GR. To support my claim, we now calculate gravitational time dilation in ES. Let "r" and "b" be two identical clocks far away from Earth. Initially, they move next to each other in the same axis d_4. At some time, "b" is sent in free fall towards Earth in the axis d_1 of "r" (Fig. 3). The kinetic energy of "b" with the mass m is

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

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

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

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

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

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

where $\gamma_{\text{gr}} = (1 - 2GM/(rc^2))^{-0.5}$ is the same dilation factor as in GR. Eq. (16) tells us: GR works so well because γ_{gr} is recovered when projecting ES to d_4. Thus, GPS satellites do their job in ER just as well as in GR! When "b" returns to "r", the time displayed by "b" is behind the time displayed by "r". This dilation stems from projecting curved geodesics. In GR, it stems from a curved spacetime. *Let us summarize time dilation:* In SR/ER, a moving clock is slow with respect to an observer. In GR/ER, a clock in a stronger gravitational field is slow with respect to an observer. In SR/GR, an observed clock is slow in its flow of time. In ER, an observed clock is slow in the observer's flow of time. Since γ and γ_{gr} are recovered in ER, the Hafele–Keating experiment [19] is in line with ER, too.

Three instructive examples (Fig. 4) demonstrate how to project from ES to 3D space. Problem 1: A rocket moves along a guide wire. In ES, rocket and wire move at the speed c. We assume that the wire moves in its axis d_4. As the rocket moves along the wire, its speed in d_4 must be slower than c. Wouldn't the wire eventually be outside the rocket? Problem 2: A mirror passes a rocket. An observer in the rocket's tip sends a light pulse to the mirror and tries to detect the reflection. In ES, all objects move at the speed c, but in different directions. We assume that the observer moves in his axis d_4. How can he ever detect the reflection? Problem 3: Earth revolves around the sun. We assume that the sun moves in its axis d_4. As Earth covers distance in d_1, d_2, d_4, its speed in d_4 must be slower than c. Wouldn't the sun escape from the orbital plane of Earth?
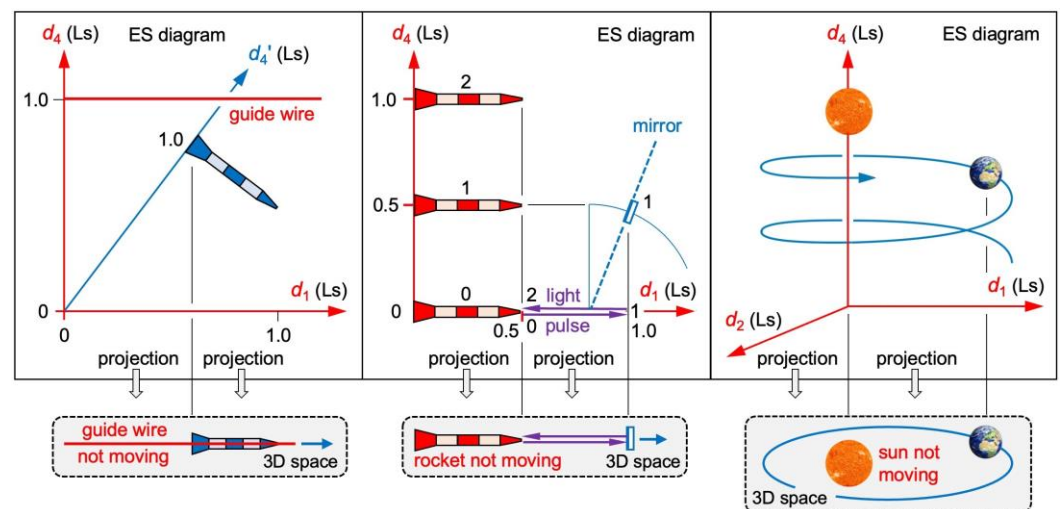
Figure 4. Graphical solutions to three geometric paradoxes. **Left:** A rocket moves along a guide wire. In 3D space, the guide wire remains within the rocket. **Center:** An observer in a rocket's tip tries to detect the reflection of a light pulse. Between two snapshots (0–1 or 1–2), rocket, mirror, and light pulse move 0.5 Ls in ES. In 3D space, the light pulse is reflected back to the observer. **Right:** Earth revolves around the sun. In 3D space, the sun remains in the orbital plane of Earth.

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

5. Solving 15 Fundamental Mysteries of Physics

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

5.1. Solving the Mystery of Time

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

5.2. Solving the Mystery of Time's Arrow

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

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

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

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

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

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

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

5.4. Solving the Mystery of Length Contraction and Time Dilation

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

5.5. Solving the Mystery of Gravitational Time Dilation

ER discloses that gravitational time dilation stems from projecting curved geodesics in ES to the axis d_4 of an observer. If an object accelerates in his proper space, it automatically decelerates in his proper time. Of course, more research will be necessary that covers gravitation and gravitational effects in ER. In GR, gravitational time dilation stems from a curved spacetime. In Sects. 5.6 through 5.11, I will show that an ER-based model of cosmology outperforms the GR-based Lambda-CDM model.

5.6. Solving the Mystery of the Cosmic Microwave Background 361

In this section, I outline an ER-based model of cosmology. There is no need to create 362
ES. Space exists just like numbers. For some reason, there was a Big Bang. In the GR-based 363
Lambda-CDM model, the Big Bang occurred "everywhere" because space inflated from a 364
singularity. In the ER-based model, we can localize the Big Bang: It injected a huge amount 365
of energy into a non-inflating and non-expanding ES all at once at what I call "origin O", 366
the only natural reference point. *The Big Bang was a singularity in provided energy.* Initially, 367
all energy receded radially from O at the speed c. Thus, the Big Bang also provided radial 368
momentum. Today, all energy is confined to a 4D hypersphere with the radius r. A lot of 369
energy is confined to its 3D hypersurface, which is expanding at the speed c. Interactions 370
(such as the isotropic emission of photons or transversal acceleration) caused some energy 371
to depart from its radial motion while keeping the speed c. 372

Shortly after the Big Bang, energy was highly concentrated in ES. In the projection to 373
any reality, a very hot and dense plasma was created. While this plasma was expanding, 374
it cooled down. During plasma recombination, radiation was emitted, which we observe 375
as cosmic microwave background (CMB) today [20]. At temperatures of roughly 3,000 K, 376
hydrogen atoms formed. The universe became more and more transparent for the CMB. 377
In the Lambda-CDM model, this stage was reached 380,000 years "after" the Big Bang. In 378
the ER-based model, these are 380,000 light years "away from" the Big Bang. If there was 379
no cosmic inflation (see Sect. 5.9), the value "380,000" needs to be recalculated. 380

In Fig. 5, nature is described from the perspective of Earth (Earth moves vertically!). 381
A lot of energy moves radially: It keeps the radial momentum provided by the Big Bang. 382
The CMB in Fig. 5 left moves transversally to d_4. It cannot move in d_4 because it already 383
moves in d_1 at the speed c. Now we interpret three observations: (1) The CMB is nearly 384
isotropic because it was created equally in the 3D space d_1, d_2, d_3 of an observer's reality. 385
(2) The temperature of the CMB is very low because of a very high recession speed v'_{3D} 386
(see Sect. 5.10) of all involved plasma particles. (3) We still observe the CMB today because 387
it started moving at a very low speed $c' \ll c$ in a very dense medium. 388

389
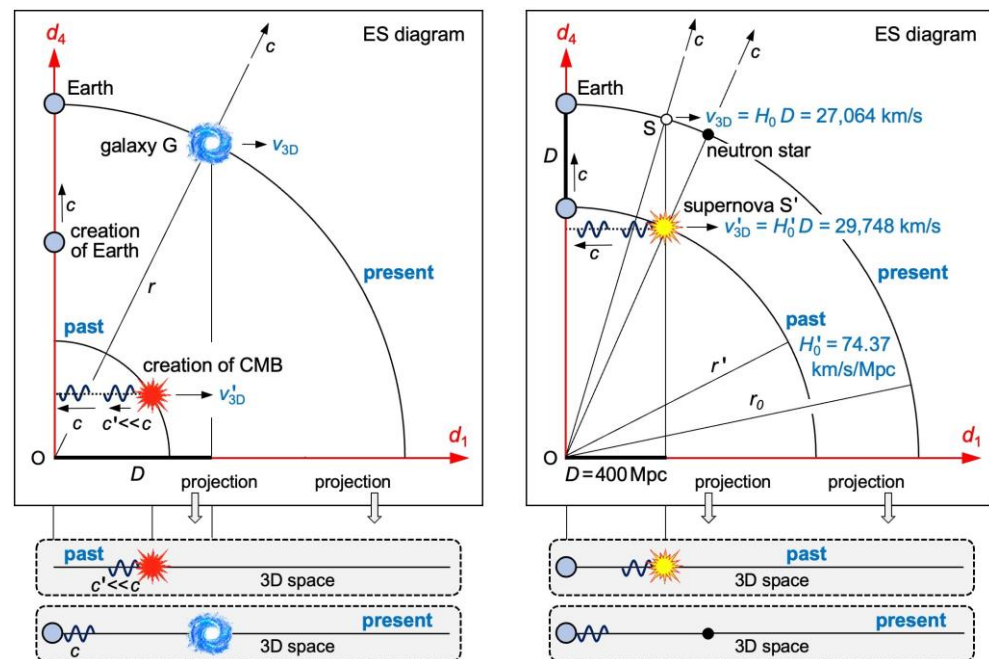
Figure 5. ES diagrams and 3D projections for solving the mysteries 5.6, 5.7, and 5.10. The displayed 390
circular arcs are part of a 3D hypersurface, which is expanding in ES at the speed c. **Left:** The CMB 391
was created in the past and started moving at a speed $c' \ll c$. The galaxy G is receding from Earth 392
today at the speed v_{3D}. **Right:** A supernova S' occurred in the past when the radius r' of the hyper- 393
surface was smaller than today's radius r_0. It occurred at the distance of $D = 400$ Mpc from Earth. 394
If a supernova S occurs today at the same distance D, it recedes slower than S'. 395

5.7. Solving the Mystery of the Hubble–Lemaître law

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

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

where $H_t = c/r = 1/t$ is the Hubble parameter and t is the cosmic time elapsed since the Big Bang. Eq. (19) is the Hubble–Lemaître law [21,22]: The farther a galaxy, the faster it is receding from Earth. Cosmologists are already aware that H_t is a parameter rather than a constant. They are not yet aware of the 4D Euclidean geometry.

5.8. Solving the Mystery of the Flat Universe

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

5.9. Solving the Mystery of Cosmic Inflation

It is assumed that a cosmic inflation of space in the early universe [23,24] caused the isotropic CMB, the flatness of the universe, and large-scale structures (inflated from quantum fluctuations). I just demonstrated that ER explains the first two observations. ER also explains the third observation if we assume that the impacts of quantum fluctuations have been expanding in ES at the speed c. ***In ER, cosmic inflation is an obsolete concept.***

5.10. Solving the Mystery of the Hubble Tension

There are several methods for calculating the Hubble constant $H_0 = c/r_0$, where r_0 is today's radius of the 4D hypersphere. Up next, I explain why the calculated values of H_0 do not match (known as the "Hubble tension"). I compare measurements of the CMB using the *Planck space telescope* with calibrated distance ladder techniques using the *Hubble space telescope.* According to team A [25], there is $H_0 = 67.66 \pm 0.42$ km/s/Mpc. According to team B [26], there is $H_0 = 73.52 \pm 1.62$ km/s/Mpc. Team B made efforts to minimize the error margins in the distance measurements. I will show that misinterpreting the redshift data causes a systematic error in team B's calculation of H_0. We assume that the value of team A is correct. We now simulate a supernova S' at the distance of $D = 400$ Mpc. If this supernova occurred today (S in Fig. 5 right), we would calculate from Eq. (19)

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

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

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

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

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

Since team B is not aware of Eq. (22), it concludes that 74.37 km/s/Mpc would be the value of H_0. In truth, team B ends up with a value $H_{t'}$ of the past. For a short distance of $D = 400$ kpc, Eq. (22) tells us that $H_{t'}$ deviates from H_0 by only 0.009 percent. But when

plotting v'_{3D} versus D for long distances (50 Mpc, 100 Mpc, ..., 450 Mpc), the slope $H_{t'}$ is 8 to 9 percent higher than H_0, which solves the Hubble tension. I ask team B to recalculate H_0 after converting all v'_{3D} to today's value v_{3D}. Eq. (22) tells us how to do so:

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

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

Of course, team B is well aware of the fact that the supernova's light was emitted in the past. But in the Lambda-CDM model, all that counts is the timespan during which the light is moving to Earth. Along the way, each wavelength λ_{emit} is continuously stretched by expanding space. Thus, the redshift parameter z is increasing during the journey to Earth. That moment when the supernova occurred is irrelevant. In the ER-based model, that moment is relevant, but the timespan is irrelevant. Each λ_{emit} is initially redshifted at the cosmic time t' by the Doppler effect. During the journey to Earth, the redshift parameter z' remains constant. It is tied up in a "package" when the supernova occurs and sent to Earth, where it is measured. A 3D hypersurface (defined by its contained energy!) is expanding in 4D space. ***In ER, expansion of space is an obsolete concept.***

5.11. Solving the Mystery of Dark Energy

Team B can fix the systematic error in its calculation of H_0 within the Lambda-CDM model by converting all v'_{3D} to v_{3D} according to Eq. (25). Now I reveal another systematic error that is inherent in the Lambda-CDM model itself. It has to do with assuming an accelerating expansion of space, and it can only be fixed by replacing that model with the ER-based model of cosmology (unless we postulate a dark energy). Today's cosmologists [27,28] favor an accelerating expansion of space because the calculated recession speeds deviate from the values predicted by Eq. (19). The deviations increase with distance, and an accelerating expansion of space would stretch each λ_{emit} even more.

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

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

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

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

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

Fig. 6 shows the distance modulus μ of 16 low-redshift and 24 high-redshift supernovae versus v'_{3D}/c. Low-redshift data were published by Hamuy *et al* [29], high-redshift data by Perlmutter *et al* [27]. I considered those supernovae that had been studied by both [27] and [30]. For all 40 supernovae, I calculated v_{3D} from Eq. (26). Then I used Eq. (27), $D = 10^{0.2\mu+1}$, and $r_0 = 14.25$ Gpc to calculate v'_{3D}.

498
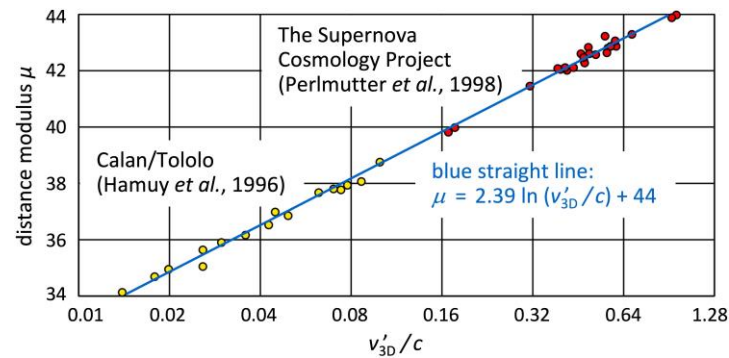
Figure 6. Hubble diagram for 40 Type Ia supernovae. The horizontal axis displays adjusted speeds. 499
All data including their uncertainties are listed in the Appendix A. 500

Linear regression yields the blue straight line in Fig. 6. The equation is given by 501

502

$$v'_{3D} \;=\; H_0^* \, D \;,\qquad\qquad (28)$$ 503

504

where H_0^* is a true constant. The offset "44" in Fig. 6 relates to $H_0^* \approx 48\,\text{km/s/Mpc}$ (see 505
Appendix B). H_0^* is lower than H_0 in the Lambda-CDM model, but it is not the task of ER 506
to recover a value that stems from a different spacetime. Only in ER do all 40 supernovae 507
(including the high redshifts) fit very well to a straight line. Eq. (28) is the correct Hubble– 508
Lemaître law. Space is not expanding, but energy is receding. The term "dark energy" [31] 509
was coined to explain an accelerating expansion of space. There is no expansion of space. 510
In ER, dark energy is an obsolete concept. It has never been observed anyway. 511

Any expansion of space (uniform as well as accelerating) is only virtual. There is no 512
accelerating expansion of the Universe even if the Nobel Prize in Physics 2011 was given 513
"for the discovery of the accelerating expansion of the Universe through observations of 514
distant supernovae" [32]. This praise comes with two misconceptions: (1) In the Lambda-515
CDM model, the term "Universe" implies space, but space is *not expanding* at all. (2) There 516
is receding energy, but it recedes *uniformly* at the speed c. In each observer's reality, there 517
only seems to be an accelerating expansion of space. 518

Radial momentum provided by the Big Bang drives all galaxies away from the origin 519
O. They are driven by themselves rather than by dark energy. If the 3D hypersurface has 520
always been expanding at the speed c, the time elapsed since the Big Bang is $1/H_0^*$, which 521
is 20.4 billion years rather than 13.8 billion years [33]. The new estimate would explain the 522
existence of stars as old as 14.5 billion years [34]. Table 1 compares two models of cosmol-523
ogy. Be aware that "Universe" (capitalized) in the Lambda-CDM model is not the same as 524
"universe" in the ER-based model. In the next two sections, I will demonstrate that ER is 525
compatible with QM. Since "quantum gravity" is meant to make GR compatible with QM, 526
I conclude: *In ER, quantum gravity is an obsolete concept.* 527

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

528

Table 1. Comparing the Lambda-CDM model with the ER-based model of cosmology. 529

5.12. Solving the Mystery of the Wave–Particle Duality

The wave–particle duality was first discussed by Niels Bohr and Werner Heisenberg [35] and has bothered physicists ever since. Electromagnetic waves are oscillations of an electromagnetic field, which propagate through 3D space at the speed c. In some experiments, objects behave like waves. In other experiments, the same objects behave like particles. Up next, I explain how the very same object (here: an electromagnetic wave packet) can be deemed both wave and particle. From an observer's perspective, it is a wave. From its own perspective, it is a particle. The following arguments hold for gravitational waves, too, if the electromagnetic field is replaced with a gravitational field.

To understand the duality, we use a generalized concept of energy: All energy in ES is made up of quanta that may appear as wave packets and particles for different observers. In Fig. 7, such an energy quantum "wp" (wave packet) is illustrated. If I observe "wp" (external view, coordinate spacetime), I deem it wave: It propagates in my axis x_1 at the speed c, and it oscillates in my axes x_2 and x_3 (electromagnetic field). Propagating and oscillating occur in coordinate time t. However, "wp" has features of a particle, too: From its own perspective (internal view or "in-flight view", not available in SR/GR), the axis of its 4D motion disappears because of length contraction at the speed c. Thus, "wp" deems itself particle at rest. The four dimensions of space enable this internal view.
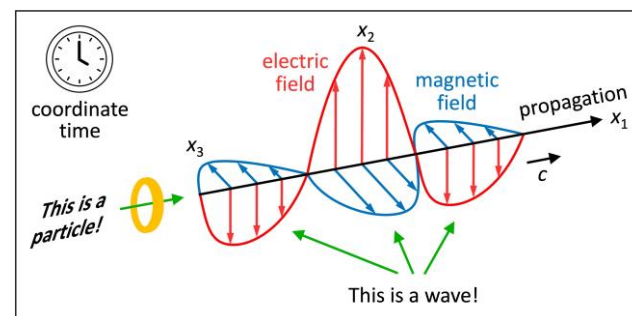
Figure 7. Artwork illustrating how the very same object can be deemed both wave and particle. If I observe a wave packet (external view), it comes in four orthogonal dimensions: propagation, electric field, magnetic field, and coordinate time. I deem it wave. From its own perspective (internal view, not available in SR/GR), the wave packet deems itself particle at rest.

Only the SO(4) symmetry of ES tells us that wave and particle are subjective concepts: *What I deem wave, deems itself particle at rest.* Albert Einstein once demonstrated that energy is equivalent to mass [36]. This equivalence manifests itself in the wave–particle duality: Since each wave packet moves through ES at the speed c, the axis of its 4D motion disappears for itself. That is to say: From its own perspective (in its own reality), all of its energy "condenses" to what we call "mass" in a particle at rest.

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

The wave–particle duality is also observed in matter, such as electrons [37]. Electrons are energy quanta, too. From the internal view (if I track a single electron), this electron is a particle: Which slit will it pass through? From the external view (if I observe an electron without tracking it), this electron behaves like a wave. Because I automatically track slow objects (slow for me), I deem all macroscopic objects matter rather than waves. This argument justifies drawing solid rockets and celestial bodies in my ES diagrams.

5.13. Solving the Mystery of Non-Locality

The term "entanglement" [38] was coined by Erwin Schrödinger in his comment on the Einstein–Podolsky–Rosen paradox [39]. These three physicists argued that QM would not provide a complete description of reality. Schrödinger's word creation did not solve the paradox, but it demonstrates our difficulties in comprehending QM. John Bell proved that QM is not compatible with local hidden-variable theories [40]. Several experiments have confirmed that entanglement violates the concept of locality [41–43]. Ever since has entanglement been considered a non-local effect.

Now I show how to untangle entanglement *without the concept of non-locality.* All we have to do is discuss it in ES: The fourth dimension of space makes non-locality obsolete. Fig. 8 displays two wave packets that were created at once at a point P and are now moving away from each other in opposite directions $\pm d_4'$ at the speed c. These wave packets are entangled. For an observer moving in a direction other than $\pm d_4'$ (external view), they appear as two distinct objects. The observer cannot understand how the two wave packets communicate with each other in no time.
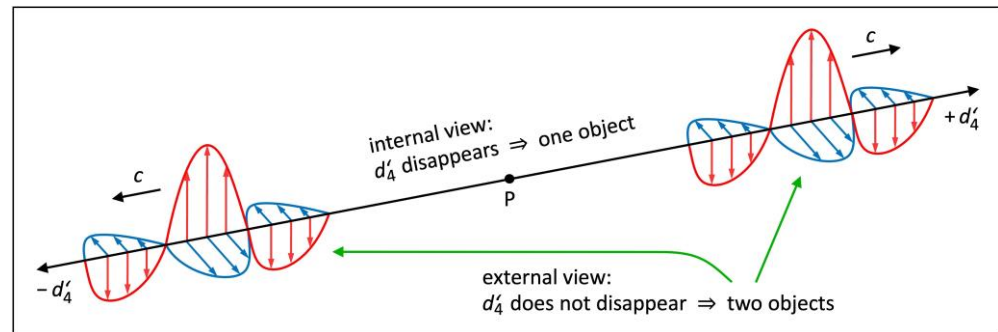
Figure 8. Entanglement in ES. For an observer moving in a direction other than $\pm d_4'$ (external view), the displayed wave packets appear as two distinct objects. For each wave packet (internal view), the axis $\pm d_4'$ disappears because of length contraction. In this view, the wave packets are one object.

For each wave packet in Fig. 8 (internal view), the axis $\pm d_4'$ disappears because of length contraction at the speed c. In their common (!) proper space spanned by d_1', d_2', d_3', either one deems itself at the very same position as its twin. From either perspective, they are one object, which has never been separated. This is how they communicate with each other in no time. There is no "spooky action at a distance". The twins stay together in their proper space even if their proper time flows in opposite directions. Entanglement occurs because an observer's proper space *may be different* from an observed object's proper space. This is possible only if there are four dimensions of space. ER also explains entanglement of electrons or atoms. They move at a speed $v_{3D} < c$ in my proper space, but in their axis $\pm d_4'$ they move at the speed c. Any measurement tilts the axis of 4D motion of one twin and thus destroys the entanglement. ***In ER, non-locality is an obsolete concept.***

5.14. Solving the Mystery of Spontaneous Effects

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

5.15. Solving the Mystery of the Baryon Asymmetry   616

According to the Lambda-CDM model, almost all matter in the Universe was created   617
shortly after the Big Bang. Only then was the temperature high enough to enable the pair   618
production of baryons and antibaryons. But the density was also very high so that baryons 619
and antibaryons should have annihilated each other again. Since we do observe a lot more   620
baryons than antibaryons today (known as the "baryon asymmetry"), it is assumed that   621
an excess of baryons must have been produced in the early Universe [44]. However, such   622
an asymmetry in pair production has never been observed.   623

ER solves the baryon asymmetry: Because each energy quantum deems itself particle,   624
there were particles in ES immediately after the Big Bang. *There are much less antiparticles* 625
than particles today because antiparticles are created in pair production only. One may ask: Why 626
do energy quanta deem themselves particles rather than antiparticles? The answer is that   627
antiparticles are not the opposite of particles. An antiparticle is a particle, too, but with the 628
opposite electric charge. Antiparticles seem to flow backward in time because proper time 629
flows in opposite directions for any two quanta created in pair production. As they move   630
in opposite directions at the speed c, they are automatically entangled.   631

6. Conclusions   632

ER solves mysteries, which SR/GR either have not solved in 100+ years or which have   633
been solved, but only with concepts that are obsolete in ER: cosmic inflation, expansion of 634
space, dark energy, quantum gravity, non-locality. Today's physics needs these concepts   635
to make cosmology and QM work, but we should drop concepts that prove to be obsolete   636
(Occam's razor). On the other hand, there are waves (electromagnetic, gravitational), but 637
the SO(4) symmetry of ES is not compatible with waves. I thus suggest that we distinguish 638
between the master reality ES described by ER (without waves) and an observer's reality   639
described by SR/GR (with waves). I demonstrated that there is a lot more physics beyond   640
an observer's reality. The true pillars of physics are ER and QM.   641

SR/GR have been confirmed many times over. Thus, they are considered two of the   642
greatest achievements of physics. I showed that their performance is limited, and I suspect 643
that this limitation causes today's stagnation in physics. Physicists feel comfortable with 644
SR/GR, but if we think of an observer's reality as an oversized stage, the keys to cosmology 645
and QM are beyond the curtain of this stage. Only in natural spacetime does nature dis-   646
close her secrets. We must not think that an impressive confirmation of ER would still be 647
missing. A holistic view of nature is a necessary requirement for solving 15 fundamental   648
mysteries, such as the Hubble tension, dark energy, and non-locality.   649

It was a wise decision to award Albert Einstein the Nobel Prize for his theory of the 650
photoelectric effect [45] rather than for SR/GR. ER penetrates to a deeper level. Einstein, 651
one of the most brilliant physicists ever, failed to realize that the fundamental metric cho- 652
sen by nature is Euclidean. He sacrificed absolute space and time. I sacrifice the absolute- 653
ness of waves and particles, but I do restore absolute time (cosmic time). For the first time, 654
mankind understands the nature of time: Time is distance covered in ES divided by the   655
speed c. The human brain is able to imagine that we move through 4D space at the speed   656
of light. With that said, conflicts of mankind become all so small.   657

Final remarks: (1) I addressed gravitation only briefly, but I ask you once more to be 658
patient and fair. We should not reject ER just because gravitational effects are not yet fully 659
understood. It is promising that ER predicts the same gravitational lensing and the same   660
perihelion precession of elliptical orbits as GR [11]. (2) The beauty of ER is its symmetry. 661
But to cherish ER we must give ourselves a push by accepting that an observer's reality is 662
a projection. We must not ask in physics: Why is it a projection? Nor must we ask: Why is 663
it a probability function? (3) It looks like Plato was right with his *Allegory of the Cave* [46]: 664
Mankind experiences a projection that is blurred because of QM. It is not by chance that   665
the author of this paper is an experimental physicist. The construed concepts of spacetime 666
in SR/GR are not suspicious to theorists. This paper lays the groundwork for ER. Everyone 667
is welcome to join in! May ER now get the broad acceptance that it deserves.   668

Acknowledgements: I would like to thank Siegfried W. Stein for his contribution to Sect. 5.10 and for the Figs. 2, 4 (partly), and 5. After several unsuccessful submissions, he eventually decided to withdraw his co-authorship. I thank Matthias Bartelmann, Dirk Rischke, Jürgen Struckmeier, and Andreas Wipf for some valuable comments. In particular, I thank all editors and reviewers for the precious time that they spent on my manuscript.

Comments: It takes open-minded and courageous reviewers to evaluate a theory that comes with a paradigm shift. Reviewers who stick to traditional concepts are paralyzing the progress in physics. Unfortunately, several friends and colleagues refused their support because they feared about their good reputation. I was often asked to give up. In the end, I succeeded in disclosing an issue in SR/GR and in formulating a theory that is even more general than GR. I add these comments to encourage young scientists to stand up for new ideas if are promising. However, opposing the mainstream can be exhausting at times. Here are just some anonymized comments that I received from reviewers of top journals: "Unscholarly research." "This is fake science." "The math is too simple to be true." The editor-in-chief of a top journal told me that he will not even look at my manuscript: "Publishing is for experts only!" A well-known preprint repository suspended my submission privileges.

Conflict of Interest: The author has no competing interests to declare.

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

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

Appendix A

All data displayed in Fig. 6 including their uncertainties.

Col. 1: IAU name assigned to the supernova.
Col. 2: Redshift z according to [27].
Col. 3: Uncertainty in z according to [27].
Col. 4: Distance modulus μ according to [30].
Col. 5: Uncertainty in μ according to [30].
Col. 6: Distance D in parsec calculated from $D = 10^{0.2\mu+1}$.
Col. 7: v_{3D}/c calculated from Eq. (26).
Col. 8: v'_{3D}/c calculated from Eq. (27).

SN	z	σ_z	μ	σ_μ	D (pc)	v_{3D}/c	v'_{3D}/c
1990O	0.030	0.002	35.90	0.20	1.514E8	0.0296	0.0299
1990af	0.050	0.002	36.84	0.21	2.333E8	0.0488	0.0496
1992P	0.026	0.002	35.64	0.20	1.343E8	0.0257	0.0259
1992ae	0.075	0.002	37.77	0.19	3.581E8	0.0722	0.0741
1992ag	0.026	0.002	35.06	0.24	1.028E8	0.0257	0.0259
1992al	0.014	0.002	34.12	0.25	6.668E7	0.0139	0.0140
1992aq	0.101	0.002	38.73	0.20	5.572E8	0.0959	0.0998
1992bc	0.020	0.002	34.96	0.22	9.817E7	0.0198	0.0199
1992bg	0.036	0.002	36.17	0.19	1.714E8	0.0354	0.0358
1992bh	0.045	0.002	36.97	0.18	2.477E8	0.0440	0.0448
1992bl	0.043	0.002	36.53	0.19	2.023E8	0.0421	0.0427
1992bo	0.018	0.002	34.70	0.23	8.710E7	0.0178	0.0179
1992bp	0.079	0.002	37.94	0.18	3.873E8	0.0759	0.0780
1992br	0.088	0.002	38.07	0.28	4.111E8	0.0841	0.0866
1992bs	0.063	0.002	37.67	0.19	3.420E8	0.0610	0.0625
1993B	0.071	0.002	37.78	0.19	3.597E8	0.0685	0.0703

1995ar	0.465	0.005	42.81	0.22	3.648E9	0.3643	0.4896
1995as	0.498	0.001	43.21	0.24	4.385E9	0.3835	0.5540
1995aw	0.400	0.030	42.04	0.19	2.559E9	0.3243	0.3953
1995ax	0.615	0.001	42.85	0.23	3.715E9	0.4457	0.6029
1995ay	0.480	0.001	42.37	0.20	2.979E9	0.3731	0.4717
1995ba	0.388	0.001	42.07	0.19	2.594E9	0.3166	0.3871
1996cf	0.570	0.010	42.77	0.19	3.581E9	0.4228	0.5647
1996cg	0.490	0.010	42.58	0.19	3.281E9	0.3789	0.4922
1996ci	0.495	0.001	42.25	0.19	2.818E9	0.3818	0.4759
1996cl	0.828	0.001	43.96	0.46	6.194E9	0.5393	0.9540
1996cm	0.450	0.010	42.58	0.19	3.281E9	0.3554	0.4617
1997F	0.580	0.001	43.04	0.21	4.055E9	0.4280	0.5982
1997H	0.526	0.001	42.56	0.18	3.251E9	0.3992	0.5172
1997I	0.172	0.001	39.79	0.18	9.078E8	0.1574	0.1681
1997N	0.180	0.001	39.98	0.18	9.908E8	0.1640	0.1763
1997P	0.472	0.001	42.46	0.19	3.105E9	0.3684	0.4710
1997Q	0.430	0.010	41.99	0.18	2.500E9	0.3432	0.4162
1997R	0.657	0.001	43.27	0.20	4.508E9	0.4660	0.6816
1997ac	0.320	0.010	41.45	0.18	1.950E9	0.2707	0.3136
1997af	0.579	0.001	42.86	0.19	3.733E9	0.4275	0.5792
1997ai	0.450	0.010	42.10	0.23	2.630E9	0.3554	0.4358
1997aj	0.581	0.001	42.63	0.19	3.357E9	0.4285	0.5606
1997am	0.416	0.001	42.10	0.19	2.630E9	0.3345	0.4102
1997ap	0.830	0.010	43.85	0.19	5.888E9	0.5401	0.9205

Appendix B

Estimation of H_0^*.

$$\mu \;=\; 2.39 \ln(v'_{3D}/c) + 44$$

$$5 \log D - 5 \;=\; 2.39 \ln(v'_{3D}/c) + 44$$

$$\ln D / \ln 10 \;=\; 0.478 \ln(v'_{3D}/c) + 9.8$$

$$\ln D \;=\; 1.1 \, \ln(v'_{3D}/c) + 22.6$$

$$D \;\approx\; (v'_{3D}/c) \times 6.31E9$$

$$v'_{3D} \;\approx\; D \times 0.048 \text{ m/s/pc}$$

$$H_0^* \;\approx\; 48 \text{ km/s/Mpc}$$

References

1. Einstein A 1905 Zur Elektrodynamik bewegter Körper *Ann. Phys.* **322** 891
2. Einstein A 1916 Die Grundlage der allgemeinen Relativitätstheorie *Ann. Phys.* **354** 769
3. Minkowski H 1910 Die Grundgleichungen für die elektromagnetischen Vorgänge in bewegten Körpern *Math. Ann.* **68** 472
4. Rossi B and Hall D B 1941 Variation of the rate of decay of mesotrons with momentum *Phys. Rev.* **59** 223
5. Dyson F W, Eddington A S and Davidson C 1920 A determination of the deflection of light by the sun's gravitational field, from observations made at the total eclipse of May 29, 1919 *Philos. Trans. R. Soc. A* **220** 291
6. Ashby N 2003 Relativity in the global positioning system *Living Rev. Relativ.* **6** 1

7. Ryder L H 1985 *Quantum Field Theory* (Cambridge University Press)
8. Newburgh R G and Phipps Jr. T E 1969 A space–proper time formulation of relativistic geometry *Phys. Sci. Res. Papers* **401**
9. Montanus J M C 1991 Special relativity in an absolute Euclidean space-time *Phys. Essays* **4** 350
10. Montanus J M C 2001 Proper-time formulation of relativistic dynamics *Found. Phys.* **31** 1357
11. Montanus H 2023 *Proper Time as Fourth Coordinate* (greenbluemath.nl/proper-time-as-fourth-coordinate/, 23 September 2023)
12. Almeida J B 2001 An alternative to Minkowski space-time (arXiv:gr-qc/0104029)
13. Gersten A 2003 Euclidean special relativity *Found. Phys.* **33** 1237
14. van Linden R 2023 Euclidean relativity (euclideanrelativity.com)
15. Newton I 1687 *Philosophiae Naturalis Principia Mathematica* (Joseph Streater)
16. Wick G C 1954 Properties of Bethe-Salpeter wave functions *Phys. Rev.* **96** 1124
17. Weyl H 1928 *Gruppentheorie und Quantenmechanik* (Hirzel)
18. Abbott B P *et al* (LIGO Scientific Collaboration and Virgo Collaboration) 2016 Observation of gravitational waves from a binary black hole merger *Phys. Rev. Lett.* **116** 061102
19. Hafele J C and Keating R E 1972 Around-the-world atomic clocks: Predicted relativistic time gains. *Science* **177** 166
20. Penzias A A and Wilson R W 1965 A measurement of excess antenna temperature at 4080 Mc/s *Astrophys. J.* **142** 419
21. Hubble E 1929 A relation between distance and radial velocity among extra-galactic nebulae *Proc. Natl. Acad. Sci. USA* **15** 168
22. Lemaître G 1927 Un univers homogène de masse constante et de rayon croissant, rendant compte de la vitesse radiale des nébuleuses extra-galactiques *Ann. Soc. Sci. Bruxelles A* **47** 49
23. Linde A 1990 *Inflation and Quantum Cosmology* (Academic Press)
24. Guth A H 1997 *The Inflationary Universe* (Perseus Books)
25. Aghanim N *et al* (Planck Collaboration) 2020 Planck 2018 results. VI. Cosmological parameters *Astron. Astrophys.* **641** A6
26. Riess A G *et al* 2018 Milky Way Cepheid standards for measuring cosmic distances and application to Gaia DR2 *Astrophys. J.* **861** 126
27. Perlmutter S *et al* (The Supernova Cosmology Project) 1998 Measurements of Ω and Λ from 42 high-redshift supernovae (arXiv:astro-ph/9812133)
28. Riess A G *et al* 1998 Observational evidence from supernovae for an accelerating universe and a cosmological constant *Astron. J.* **116** 1009
29. Hamuy M *et al* 1996 The absolute luminosities of the Calan/Tololo Type Ia supernovae *Astron. J.* **112** 2391
30. Riess A G *et al* 2004 Type Ia supernova discoveries at $z > 1$ from the Hubble Space Telescope *Astrophys. J.* **607** 665
31. Turner M S 1998 Dark matter and dark energy in the universe (arXiv:astro-ph/9811454)
32. The Nobel Prize Organisation 2011 The Nobel Prize in Physics 2011 (nobelprize.org/prizes/physics/2011/summary/)
33. Choi S K *et al* 2020 The Atacama Cosmology Telescope: a measurement of the cosmic microwave background power spectra at 98 and 150 GHz *J. Cosmol. Astropart. Phys.* **12** 045
34. Bond H E *et al* 2013 HD 140283: A star in the solar neighborhood that formed shortly after the Big Bang *Astrophys. J. Lett.* **765** L12
35. Heisenberg W 1969 *Der Teil und das Ganze* (Piper)
36. Einstein A 1905 Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig? *Ann. Phys.* **323** 639
37. Jönsson C 1961 Elektroneninterferenzen an mehreren künstlich hergestellten Feinspalten *Z. Phys.* **161** 454
38. Schrödinger E 1935 Die gegenwärtige Situation in der Quantenmechanik *Naturwissenschaften* **23** 807
39. Einstein A, Podolsky B and Rosen N 1935 Can quantum-mechanical description of physical reality be considered complete? *Phys. Rev.* **47** 777
40. Bell J S 1964 On the Einstein Podolsky Rosen paradox *Physics* **1** 195
41. Freedman S J and Clauser J F 1972 Experimental test of local hidden-variable theories *Phys. Rev. Lett.* **28** 938
42. Aspect A, Dalibard J and Roger G 1982 Experimental test of Bell's inequalities using time-varying analyzers *Phys. Rev. Lett.* **49** 1804
43. Bouwmeester D *et al* 1997 Experimental quantum teleportation *Nature* **390** 575
44. Canetti L, Drewes M and Shaposhnikov M 2012 Matter and antimatter in the universe *New J. Phys.* **14** 095012
45. Einstein A 1905 Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt *Ann. Phys.* **322** 132
46. Plato *Politeia* 514a