Article 1

Solving the Mystery of Time and Unifying Relativity with Quantum Mechanics

Markolf H. Niemz [1],* 🆔 and **Siegfried W. Stein** [2] 🆔 4

[1] Heidelberg University, Theodor-Kutzer-Ufer 1–3, D-68167 Mannheim, Germany 5
[2] no affiliation 6
* Correspondence: markolf.niemz@medma.uni-heidelberg.de 7

Abstract: Today's concept of time traces back to Albert Einstein's theories of special (SR) and general 8
relativity (GR). In SR, uniformly moving clocks are slow with respect to my clocks. In GR, clocks in 9
a more curved spacetime are slow with respect to my clocks. Many physicists anticipate that GR has 10
an issue as it isn't compatible with quantum mechanics. Here we show: "Einstein time" (Einstein's 11
concept of time) has an issue because it takes the proper time of an observer as the fourth coordinate 12
of all objects in the universe. We claim that there is a unique 4D vector "flow of time" for each object. 13
SR and GR work well as approximations, but only if we consider objects on and close to Earth, where 14
that vector is nearly the same. "Euclidean time" is distance covered in Euclidean spacetime (ES) and 15
divided by the speed of light. We replace Einstein time with Euclidean time, which takes the proper 16
time of an object as its fourth coordinate. Unlike other models of Euclidean relativity (ER), we claim 17
that reality is only formed by projecting ES to an observer's 3D space. We prove: The Lorentz factor 18
is recovered in ER; acceleration relates to a 4D rotation; ER is compatible with quantum mechanics! 19
We solve 13 mysteries, such as mc^2, gravitational time dilation, the Hubble constant, wave–particle 20
duality, and quantum entanglement. We declare four concepts of today's physics (cosmic inflation, 21
expansion of space, dark energy, non-locality) as redundant. We conclude: As ER outperforms SR 22
and GR, Occam's razor knocks out Einstein time. 23

Keywords: cosmology; gravitation; Hubble constant; wave–particle duality; quantum entanglement 24

25

1. Introduction 26

Albert Einstein coined today's concepts of space and time. His theory of special rela- 27
tivity (SR) [1] is usually interpreted in Minkowski spacetime (MS) because Hermann Min- 28
kowski's geometric interpretation [2] was very successful in explaining relativistic effects. 29
MS comes with an indefinite Minkowski metric and is limited to inertial reference frames. 30
General relativity (GR) [3] includes gravitation and turns flat MS into a curved spacetime 31
with a pseudo-Riemannian metric. SR and GR are useful for describing the world that we 32
perceive on and close to Earth. The lifetime of muons [4], the deflection of starlight during 33
a solar eclipse [5], and the accuracy of GPS are a few examples. Quantum field theory [6] 34
unifies classical field theory, SR, and quantum mechanics, but not GR. 35

Many physicists anticipate that GR has an issue as it isn't compatible with quantum 36
mechanics. In this paper, we give evidence for a basic issue in Einstein's concept of time 37
that can't be fixed by adding "compensational concepts", such as cosmic inflation or dark 38
energy. *We make three changes to the foundations of physics (new concepts of time, distance, and* 39
energy) that make relativity compatible with quantum mechanics. Be honest—isn't that reason 40
enough to give our theory a chance? We must ask this question because SR and GR have 41
meanwhile turned into a dogma that must not be questioned. One editor informed us that 42
some journals have an official policy not to consider any refutations of SR. Sorry, but why 43
is that? According to Karl Popper, any theory is scientific if and only if it is falsifiable [7]. 44
No scientific theory, not even SR or GR, is set in stone! What would science be like if edi- 45
tors weren't to consider any refutations of the geocentric model? 46

For more than 100 years, physicists have been working with a flawed concept of time. It must be permitted to make this claim now that we explain why SR and GR work so well despite that flawed concept of time. And yet, five journals rejected our submission at the editor's desk. One top journal argued that we wouldn't provide extraordinary proof for our extraordinary claims. Isn't solving 13 fundamental mysteries of physics extraordinary proof? Another journal argued that science would only deal with the observable world. Really? Do we observe time? It is irony that one of the journals, where Einstein published, refused to even look at our paper as we wouldn't be experts. What constitutes an expert? Being a specialist in dark energy that we prove to be a redundant concept?

Our theory "Euclidean relativity" (ER) comes with three postulates: (1) In Euclidean spacetime (ES), the speed of light c is both absolute and universal—all energy is moving radially away from an origin at this speed. (2) The laws of physics have the same form in each "reality" (projection of ES to an observer's 3D space). (3) All energy is "wavematter" (electromagnetic wave packet and matter in one). Our first postulate of ER is stronger than Einstein's second postulate of SR. Everything is moving through ES at the same speed c. Our second postulate is the same as Einstein's first postulate, except that ER isn't limited to inertial frames and that we distinguish ES from an observer's reality. Our third postulate paves the way for unifying relativity and quantum mechanics.

We aren't the first physicists to investigate ER: In the early 1990s, Montanus made a first attempt to describe ES [8]. He also explored relativistic dynamics in ES [9]. Almeida tried to implement electrodynamics and gravitation 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 by conceiving of ES as an observer's reality, all these models run into geometric paradoxes (to be discussed in Sect. 4). Only Machotka [14] added a "boundedness postulate" to avoid such paradoxes, but that postulate sounds contrived. We overcome paradoxes for good by limiting reality with our second postulate: *Reality is only formed by projecting ES to an observer's 3D space.*

It is helpful to compare our theory with Newton's physics and Einstein's physics. In Newton's physics, all objects are moving through a non-deformable 3D space as a function of independent time. The speed of matter is $v_{3D} \ll c$. In Einstein's physics, all objects are moving through a deformable 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 a non-deformable ES given by 4D distance (all distances are measured in light seconds), where time is a subordinate quantity derived from covered distance. The 4D speed of everything in ES is $u_{4D} = c$. Immanuel Kant [15] provided the philosophical framework of Newton's physics. Check out whether ER could be the philosophical framework of cosmology and quantum mechanics.

We kindly ask all readers including editors and reviewers: *Be willing to question Einstein's concept of time.* Otherwise, you won't understand! Here is a short roadmap of how we proceed: We start in Sect. 2 by revealing that there is an issue in Einstein's concept of time). In Sect. 3, we offer an intuitive approach to Euclidean time. Instead of synchronizing clocks, we let a circle expand at the speed of light and then replace that circle with a sphere and a hypersphere. In Sect. 4, we derive the same Lorentz factor in ER as in SR. In Sect. 5, we solve 13 mysteries and declare four concepts of today's physics as redundant. In our Conclusions, Occam's razor knocks out Einstein's concept of time.

2. An Issue in Einstein's Concept of Time

The concept of time in today's physics traces back to Albert Einstein. For this reason, we call it "Einstein time". § 1 of SR [1] is an instruction of how to synchronize two clocks at the positions A and B. At "A time" t_A, an observer sends a light pulse from A towards B. At "B time" t_B, the light pulse is reflected at B towards A. And at "A time" t_A^*, the light pulse is back at A. Both clocks synchronize if

$$t_B - t_A = t_A^* - t_B . \tag{1}$$

In § 3 of SR [1], Einstein derives the Lorentz transformation from his synchronization procedure and from Eq. (1). 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

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

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

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

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

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

Millions of physicists read Einstein's paper on SR [1], but didn't object to it. Of course, we may subtract t_A from t_B in Eq. (1) if "A time" and "B time" are the same scalars. And indeed, our theory reveals that this assumption is a good approximation for all positions A and B on Earth or in our solar system. *SR and GR work very well as long as we describe the world on and close to Earth.* Yet Einstein's Eq. (1) runs into a very big problem once "A time" flows in a different direction than "B time". We claim that "A time" (or "B time") is the absolute value of a 4D vector "flow of time" at A (or else B). In this general case, Eq. (1) is no longer applicable, but must be replaced with a vector subtraction.

Albert Einstein was a theoretical physicist, and from his mathematical point of view there aren't any objections against Eq. (1). Yet as we will prove in this paper, 13 mysteries of physics can all be solved if we only assume that there is a 4D vector "flow of time". So, Einstein time does have an issue if it is evaluated from the perspective of physics. In Eq. (1), Einstein assumes that the time t_B of any object in the universe flows in the very same direction as the time t_A of an observer. So, Einstein time is egocentric! *It takes the proper time of an observer as the fourth coordinate of all objects in the universe.* No wonder that there are unsolved mysteries in cosmology and in quantum mechanics, where the "big picture" matters much more than the egocentric perspective of an observer.

In order to find an alternative concept of time, we now take a closer look at the effect of time dilation. Eq. (2d) tells us that there is a dilation in Einstein time: The time t in the system K is dilated by the factor of γ to yield the time t' in the system K'. That is to say: Clocks of an observer B in K' are slow with respect to clocks of an observer R in K by the factor of γ. Time dilation by the factor of γ has been experimentally confirmed. So, any alternative concept of time must give rise to an Einstein time dilation by the same factor of γ. **Now watch out as the next sentences are the most enlightening part of our paper:** Most physicists aren't aware that there are two variables in which this time dilation can be stored. Einstein and Minkowski assumed that clocks of B are slow with respect to R in the variable t'. Yet there is another variable in which clocks of B can be slow with respect to R: They can be slow in the variable t, as we will explain up next.

Fig. 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 display that moment when the red rocket has moved 1 s in time. 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 Fig. 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 0.8 s in t' *because of time dilation.*
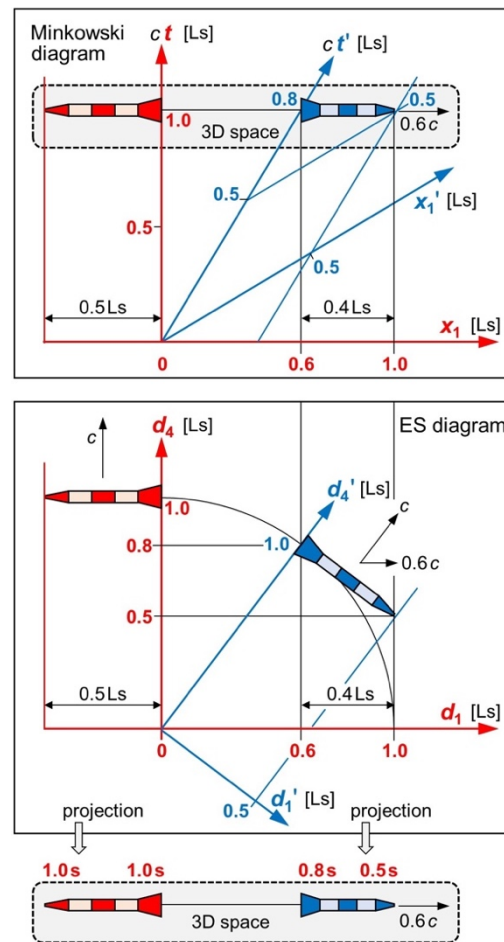
Figure 1. Minkowski diagram, ES diagram, and 3D projection for two identical rockets. **Top:** The Minkowski diagram isn't symmetric. For observer R, clocks inside the red rocket display the same time (1.0 printed in the red frame). For observer B, clocks inside the blue rocket display a different time (0.8 and 0.5 printed in the blue frame). **Center:** The ES diagram is rotationally symmetric. The values 0.8 and 0.5 are measured by R in the red frame. **Bottom:** Projection to the 3D space of R.

We now draw your attention to the values 0.8 and 0.5 printed at the blue rocket (Fig. 1 top): In § 2 of SR [1], Einstein forces clocks inside b to synchronize with clocks inside r. So, all these clocks display the same time for R: $t = 1.0$ s. Yet the clocks inside b display a different time for B: $t' = 0.8$ s and $t' = 0.5$ s. This isn't in line with experimental physics because a team of observers inside b would also synchronize all of its clocks! Reality is the other way around: Clocks inside b display the same time for B and a different time for R. We attribute the unfortunate assignment to a missing 4D vector "flow of time".

Since we claimed both rockets to be identical, we must restore the symmetry. We can do so *by rotating that blue rocket*. Such a rotation is enabled by replacing the two asymmetric dimensions x_1 and t with two symmetric dimensions of ES: d_1 and d_4 (see our Sect. 3). We end up with an ES diagram (Fig. 1 center), where the two values 0.8 and 0.5 are printed in the red frame. In SR (Fig. 1 top), clocks inside b are slow with respect to R in t'. In ER (Fig. 1 center), clocks inside b are slow with respect to R in t.

3. Introducing Euclidean Time and Euclidean Spacetime

Let us start with a very simple geometry. 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. An observer sees only the projection of that 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 that origin O. The surface is expanding at the speed c. An observer sees

only the projection of that sphere *to a flat 2D surface.* We add one dimension and imagine that all energy is in a 3D reality which is the 3D hypersurface of a 4D hypersphere around that origin O. The 3D hypersurface is expanding at the speed c. An observer sees only the projection of that 4D hypersphere *to a flat 3D space.* We claim: This third scenario describes the world that we live in. For each observer, that 4D hypersphere is projected to a unique 3D space. *The 3D hypersurface itself is absolute, but each observer's 3D space is relative.*

In all scenarios (circle, sphere, hypersphere), the radius r divided by time is always equal to c. The underlying concept of time isn't egocentric, but universal, as it originates from an absolute point (origin O). We call it "Euclidean time" τ. Time can't be observed. It is only felt as aging because the radial dimension disappears in a projection to 3D space. We define a new 4D vector "flow of time" $\boldsymbol{r}/c$, where $\boldsymbol{r}$ is pointing from O to some object. The absolute value r/c is the same for all objects, but the orientation of $\boldsymbol{r}/c$ is unique for each object. *Euclidean time itself is absolute, but each object's flow of time is relative.*

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

Eq. (3) tells us that Euclidean time isn't a primary quantity, but a subordinate quantity derived from covered distance. Distance and speed are more significant than time! So, we suggest to reconsider the units of speed and time. The universal constant c shouldn't be specified in "meters per second", but in its own new unit to be given by the community. Euclidean time should be specified in "light seconds per that new unit". These suggestions support claims by other authors [16]: Time isn't fundamental to physics.

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", we conceive of each distance (either the one radial distance r or the four axial distances d_i) as spatial and temporal distance in one. Distance isn't covered as a function of independent time. Only by covering distance in ES is Euclidean time passing by for an object! In ES, all distances are measured in "light seconds" (Ls) by odometers. There is no need to calibrate these odometers as light seconds in ES are absolute.

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 our 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. So, this formula is the Theory of Everything (TOE) in hyperspherical coordinates: "All energy is covering radial distance r which, divided by Euclidean time τ, is equal to the speed of light c."

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

Someone may argue that Eq. (4) couldn't be a TOE as it doesn't address 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. Yet as we will show in Sect. 5.4, motion in an observer's view of the hypersurface (which is his 3D space, his reality, and his "universe") is enabled by pure math—a rotation and a projection. So, Eq. (4) is the TOE in hyperspherical coordinates. Symmetry simplifies physics!

Cartesian coordinates are good for projecting 4D ES to an observer's 3D space. 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 Cartesian coordinates, too, all objects are moving at the speed of light c. Yet their 4D velocity $\boldsymbol{u}$ splits up into four components $u_i = \mathrm{d}d_i/\mathrm{d}\tau$ with

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

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 the object's flow of time $\boldsymbol{r}/c$. That is to say: *We take the proper time of an object as its fourth coordinate.* Below our ES diagrams, we project ES to an observer's 3D space. Here we are free to label the axis that we project onto. We always assume that two objects—moving relative to each other—will do so only in the axes d_1 and d_4. This is why all of our ES diagrams display d_1 and d_4. Our 3D projections display d_1. Just keep in mind that d_1 stands for d_1, d_2, d_3.

4. Geometric Effects in Euclidean Spacetime

Up next, we prove two effects in Cartesian ES coordinates: (1) If I observe a moving object, its 3D space is rotated with respect to my 3D space *causing length contraction.* (2) If I observe a moving object, its time flows in a 4D direction other than my time *causing time dilation.* So, these relativistic effects aren't unique to MS. We consider the same two rockets as in Fig. 1. They differ only in color (r = red rocket, b = blue rocket). Observer R in the rear end of the red rocket has the coordinates d_1, d_2, d_3, d_4 (red frame). Observer B in the rear end of the blue rocket has the coordinates d_1', d_2', d_3', d_4' (blue frame).

We assume that the rockets move relative to each other in 3D space (Fig. 2 bottom). As explained in Sect. 3, this 3D motion is in d_1 and d_1'. Our ES diagrams (Fig. 2 top) must fulfill three requirements: (1) According to our first postulate, either rocket must keep on moving 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 two 3D spaces of R and B.
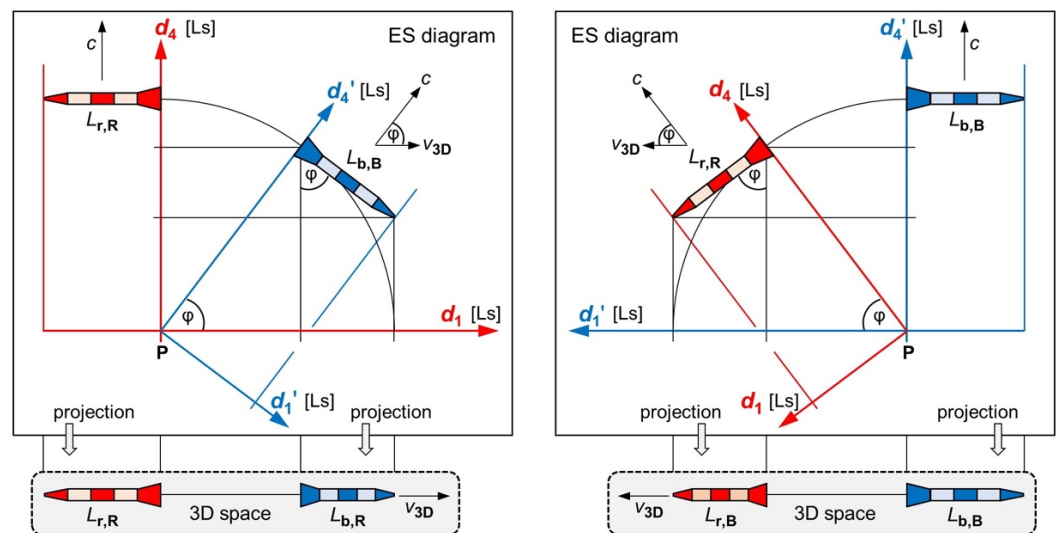

Figure 2. ES diagrams and 3D projections for two identical rockets. All axes are in Ls (light seconds). **Top left and top right:** In the ES diagrams, both rockets are moving at the speed c, but in different directions. **Bottom left:** Projection to the 3D space of R. The relative speed is v_{3D}. 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 define $L_{i,\mathrm{R}}$ (or $L_{i,\mathrm{B}}$) as length of the rocket with color i (r = red, b = blue) as seen from the perspective of observer R (or else B). From Fig. 2, we derive

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

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

where $\gamma = (1 - v_{\mathrm{3D}}^2/c^2)^{-0.5}$ is the same Lorentz factor as in SR. The blue rocket appears contracted to observer R by the factor γ^{-1}. Which distances will R observe in his axis d_4? For the answer, we mentally continue the rotation of the blue rocket (Fig. 2 top left) until it is pointing vertically down ($\varphi = 0°$) and serves as R's ruler in the axis d_4. The projection to 3D space tells us that this ruler contracts to zero: *The axis d_4 "is suppressed" (disappears) for R.* He observes a 3D space, but only feels d_4 as aging. From Fig. 2, we also derive

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

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

where $d_{4,\mathrm{B}}$ and $d'_{4,\mathrm{B}}$ are the distances that B has moved in d_4 and d'_4. With $d'_{4,\mathrm{B}} = d_{4,\mathrm{R}}$ (full symmetry in ES) and the substitutions $d_{4,\mathrm{B}} = ct_{\mathrm{B}}$ and $d_{4,\mathrm{R}} = ct_{\mathrm{R}}$, we get

$$t_{\mathrm{R}} \;=\; \gamma\, t_{\mathrm{B}} \qquad \text{(Einstein time dilation),} \tag{11}$$

where t_{R} and t_{B} are the distances that R and B have moved in the Einstein time t of R. Be aware that switching over to Einstein time turns our calculation into an approximation. In terms of Euclidean time, one has $\tau_{\mathrm{R}} = \tau_{\mathrm{B}}$. There is time dilation in ER, too: Clocks inside b are slow with respect to R in the variable t (Fig. 1 center).

The factor γ in Eqs. (8) and (11) is the same as in SR! *Despite a Euclidean metric in ER, the Lorentz factor is recovered in the projection of ES to an observer's 3D space and Einstein time.* So, the Lorentz transformation and electrodynamics are recovered in ER. Yet they are only approximations as they are based on Einstein time. The recovery is no surprise. Hermann Weyl showed that the generators of the Lorentz group are 4D rotations [17].

Now we discuss three instructive, geometric paradoxes that demonstrate the benefit of our concept "distance". Problem 1: A rocket moves along a guide wire at a high speed. The wire enters the rocket at its top and exits at its rear end. In ES, rocket and wire move at the speed c. We may assume that the wire moves in some axis d_4. As the rocket moves along the wire, it can also move in the axis d_4, but slower than the speed c. Wouldn't the wire eventually be outside the rocket? Problem 2: In billiard, the cue ball is hit to collide with the red ball. In ES, cue ball and red ball move at the speed c. We may assume that the red ball moves in some axis d_4. As the cue ball covers spatial distance to the red ball, it can also move in the axis d_4, but slower than the speed c. How can the balls ever collide if their d_4 values never match? Problem 3: An observer in the tip of a rocket watches how a mirror is passing. He 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 may assume that the rocket moves in some axis d_4. How can the observer ever detect the reflection?

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 only three distances of ES are observable! We solve all problems by projecting 4D ES to 3D space (Fig. 3). *Projections tell us what reality is like because "suppressing the axis d_4" is equivalent to "length contraction makes d_4 disappear". The 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] get caught up in paradoxes as they don't project ES to an observer's 3D space. They mistake ES for an observer's reality.
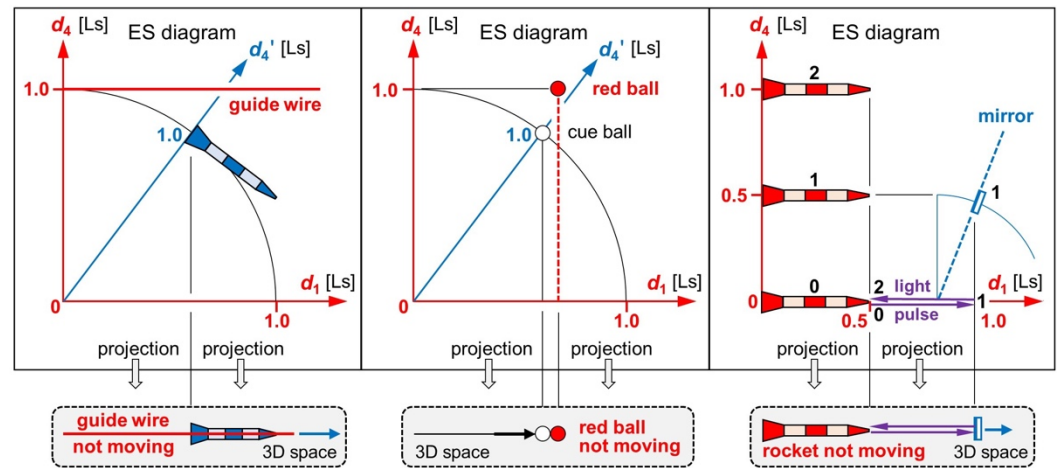
Figure 3. Graphical solutions to three geometric paradoxes. **Left:** A rocket moves along a guide wire. In 3D space, the guide wire is always within the rocket. **Center:** A cue ball is hit to collide with the red ball. In 3D space, the cue ball collides with the red ball. **Right:** An observer inside a rocket tries to detect the reflection of a short 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.

5. Solving 13 Fundamental Mysteries of Physics

We just learned that the Lorentz transformation is recovered as an approximation in ER. So, Euclidean time has no measurable consequences for SR and theories based on SR, such as electrodynamics, as long as we describe the world on and close to Earth. Up next, we show that ER outperforms SR and GR in terms of understanding and with respect to cosmology and quantum mechanics. We do so by solving 13 mysteries of physics.

5.1. Solving the Mystery of Time

Euclidean time is radial distance from an origin O in ES divided by the speed c. This is why the concept of a linear time in 3D space is only an approximation. For all observers, the radial dimension of ES disappears because of length contraction at the speed c.

5.2. Solving the Mystery of Time's Arrow

"Time's arrow" in today's physics is a synonym for time moving only forward. It has its origin in ER: We can't reverse the 4D vector "flow of time" because radial momentum provided by the Big Bang (see our Sect. 5.4) drives all energy 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

$$E = \gamma\, m\, c^2 = E_{\mathrm{kin,3D}} + m\, c^2 \, , \qquad (12)$$

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 c. ER gives us this missing clue and is thus superior to SR also in terms of understanding: *mc^2 is the kinetic energy of moving through Euclidean time (of moving in the fourth dimension).* The factor c^2 in Eq. (12) is strong evidence that everything is moving at the speed c, while it is at rest in its 3D space. c^2 is passed through to 3D space. For the same reason, there is

$$E^2 = p^2\, c^2 = p_{\mathrm{3D}}^2\, c^2 + m^2\, c^4 \, , \qquad (13)$$

where p and p_{3D} are the momenta in ES and in 3D space. In ES, an object's energy moves in the direction of its flow of time. *Dividing Eq. (13) by c^2 gives us the vector addition of an object's momentum in 3D space and its momentum mc of moving through Euclidean time.*

5.4. Solving the Mystery of the Cosmic Microwave Background   361

Now we are ready for our new model of cosmology based on ER. There is no need to   362
create ES. It exists just like numbers and can't be deformed. Because of some reason that   363
we don't know, there was a Big Bang in ES. In today's model of cosmology, it makes no   364
sense to ask *where* the Big Bang occurred: Since space and time started as a singularity and   365
space inflated thereafter, the Big Bang occurred "everywhere". In ES, it is indeed possible   366
to localize the Big Bang at what we take as our origin O. We claim that the Big Bang was   367
a sudden incident that injected a huge amount of energy into ES all at once. *Ever since has*   368
all this energy been moving radially away from O at the speed c. The adjective "sudden" allows   369
for metaphysical speculations that aren't subject of this report.   370

During the initial stage after the Big Bang, there was a huge amount of concentrated   371
energy inside ES. In the projection to any 3D space, this energy created a very dense and   372
hot plasma. While the plasma was expanding, it cooled down. During the recombination   373
of plasma particles, electromagnetic radiation was emitted that we still observe as cosmic   374
microwave background (CMB) [18]. At a temperature of roughly 3,000 K, hydrogen atoms   375
formed [19]. According to GR, this stage was reached 380,000 years "after" the Big Bang.   376
In ER, these are 380,000 light years "away from" the Big Bang. The value of 380,000 needs   377
to be recalculated if the universe has been expanding at the constant speed c.   378

Yet why is the CMB so isotropic? Here is our answer: The CMB is so isotropic because   379
it is "swinging" equally from ES into all three dimensions of my 3D space (Fig. 4). To grasp   380
the process of swinging, we mentally continue the rotation of the blue rocket in Fig. 2 top   381
left until it is pointing vertically down. We then mentally replace that blue rocket with a   382
photon and finally look at its projection to my 3D space. Here is what we learn from this   383
thought experiment: In each photon, I actually observe energy from ES whose 4D motion   384
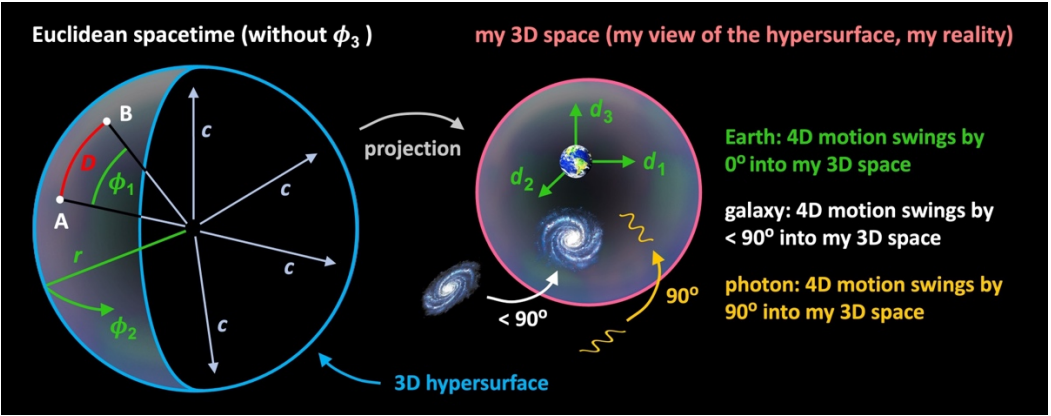swings "completely" (by an angle of 90°) into my 3D space.   385

Figure 4. Model of cosmology based on ER (not to scale). Artwork illustrating how a 3D hypersur-   387
face is expanding in ES. **Left:** Non-observable ES in hyperspherical coordinates $(\phi_1, \phi_2, \phi_3, r)$. The   388
angle ϕ_3 can't be displayed here. Hubble's law is derived from the geometry of the hypersurface.   389
Right: Projection of ES to my 3D space in Cartesian coordinates (d_1, d_2, d_3), which is my view of the   390
hypersurface and my reality. The axis d_4 (related to time) disappears because of length contraction.   391

Our eyes aren't made for *perceiving* all four dimensions of ES. Yet we can *conceive* of   392
them with our brain by employing our trick: rotating that blue rocket in Fig. 2 top left and   393
looking at its projection to 3D space. This trick tells us that the process of swinging covers   394
both operations: "Swinging" is one word for the combined action of rotating and project-   395
ing. In my 3D space, I observe the final result of this combined action.   396

We just learned that a photon is energy from ES whose 4D motion swings completely   397
into my 3D space ($v_{3D} = c$). Matter is energy from ES whose 4D motion swings "partly"   398
(by an angle of $< 90°$) into my 3D space, like that blue rocket in Fig. 2 top left ($v_{3D} < c$).   399
The swing angle of Earth is 0° because Earth doesn't move relative to myself ($v_{3D} = 0$).   400
The process of swinging enables the motion of objects in my view of the hypersurface.   401

Photons are moving in my view of the hypersurface at the speed c, while the entire hypersurface is expanding at the speed c. 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. A photon is energy from ES whose 4D motion swings completely into my 3D space. So, in the speed c of a photon I see the speed c of the hypersurface!

5.5. Solving the Mystery of Gravitational Time Dilation

Chronologically, this is the last of the 13 mysteries that we solved. Yet our solution is so beautiful that we consider it one of the strongest proofs of our theory. In ER, gravitation isn't a property of spacetime. Gravitation is acting in 3D space like the other three forces. We now calculate time dilation in the gravitational field of Earth. Clock A is far away from Earth and continuously emitting time signals at infinitesimally short intervals. Receiver B is approaching Earth and detecting these time signals. The kinetic energy of B is

$$\tfrac{1}{2}\, m\, u_{1,\mathrm{B}}^2 \;=\; G\, M\, m/r \;, \tag{14}$$

where m is the mass of B, $u_{1,\mathrm{B}}$ 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. According to our first postulate, all energy is moving through ES at the speed c. So, we get

$$u_{1,\mathrm{B}}^2 \;+\; u_{4,\mathrm{B}}^2 \;=\; 2\,G\,M/r \;+\; u_{4,\mathrm{B}}^2 \;=\; c^2 \;, \tag{15}$$

$$u_{4,\mathrm{B}}^2/c^2 \;=\; 1 \;-\; 2\,G\,M/(rc^2) \;, \tag{16}$$

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 $\mathrm{d}d_{4,\mathrm{B}} = c\,\mathrm{d}t_\mathrm{B}$ ($\mathrm{d}d_{4,\mathrm{B}}$ is the distance that B has moved in $\mathrm{d}t_\mathrm{B}$; there is no steady axis d_4' of B), we get

$$\mathrm{d}t_\mathrm{B} \;=\; (1 \;-\; 2\,G\,M/(rc^2))^{0.5}\, \mathrm{d}t_\mathrm{A} \;, \tag{17}$$

$$\mathrm{d}t_\mathrm{A} \;=\; \gamma'\, \mathrm{d}t_\mathrm{B} \;, \tag{18}$$

where $\mathrm{d}t_\mathrm{A}$ is the interval of the time signals in A's Einstein time, and $\mathrm{d}t_\mathrm{B}$ is the interval of the time signals in B's Einstein time. As in Eq. (11), Einstein time turns our calculation into an approximation. The dilation factor $\gamma' = (1 - 2GM/(rc^2))^{-0.5}$ is the same as in GR [3]. It even has the same form as in SR if we set $2GM/r = v_{3\mathrm{D}}^2$.

In order to understand how acceleration manifests itself in ES, let us assume that the blue rocket b in Fig. 2 bottom left accelerates in the axis d_1. According to Eq. (6), the speed u_1 of b must then increase at the expense of its speed u_4. That is, b is rotating in Cartesian ES coordinates! We didn't specify what caused this acceleration. *So, any acceleration in 3D space—including an acceleration caused by gravitation—relates to a 4D rotation in ES.* Gravitation causes a 4D rotation of objects in ES. I can't observe any 4D rotation in my 3D space, but I can feel gravitation as a change of my 4D vector "flow of time".

5.6. Solving the Mystery of Hubble's Law

The 3D speed $v_{3\mathrm{D}}$ at which a galaxy A (Fig. 4) is moving away from another galaxy B or Earth relates to their distance D as c relates to the radius r of the hypersurface.

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

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" $H(\tau)$.

5.7. Solving the Mystery of the Flat Universe

Because the entire hypersurface is expanding at the speed of light (Fig. 4), 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 only two dimensions of space, the 3D curvature of Earth's 2D surface disappears for the ant.

5.8. 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 assume that there had been quantum fluctuations in energy in the early hypersurface. Their impacts have been expanding at the speed of light! ***Cosmic inflation is a redundant concept.***

5.9. Solving the Mystery of the Hubble Constant

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 measurement. Yet as we will prove up next, team B's value of H_0 is wrong *because of a systematic error in the redshift measurement.* Let us assume that 67.66 km/s/Mpc would be the correct value of today's H_0. We simulate a supernova at a distance of $D = 400$ Mpc from Earth that moves at the 3D speed v_{3D} away from Earth. From Eq. (19), we calculate

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

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

where the parameter z measures how the initial wavelength λ_0 of the supernova's light is either *passively stretched by expanding space in GR* (team B)—or how it is *redshifted by the Doppler effect of actively receding galaxies in ER* (our model).

In the next paragraphs, we demonstrate that team B will measure a higher value of z, and thus calculate a higher value of v_{3D}, and thus calculate a higher value of H_0. Fig. 5 left shows the geometry of the supernova and Earth in hyperspherical coordinates. We define one circle called "past", where the supernova occurred, and a second circle called "present", where its light is observed on Earth. Today, that supernova has turned into a neutron star. Fig. 5 right shows the same geometry, but in Cartesian coordinates. Because everything in ES is moving at the speed c, Earth has moved the distance D in the axis 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'.

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

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

Because of this higher H_0' value and Eq. (19), *all data* measured by team B are related to a higher 3D speed of the past $v_{3D}' = 29{,}748$ km/s for the same D. So, team B measures

a redshift of $z' = 0.0992$ according to Eq. (21), which is indeed significantly higher than 0.0903. Team B isn't aware of Eq. (22) and of the ES geometry shown in Fig. 5. Yet because of that too high value of z', team B will calculate $v'_{3D} = 29{,}748$ km/s from Eq. (21), and $H'_0 = 74.37$ km/s/Mpc from Eq. (19). So, team B will conclude that 74.37 km/s/Mpc would be the correct value of *today's* Hubble constant. But in truth, team B ends up with a Hubble constant *of the past* as it has been relying on redshift data from the past!
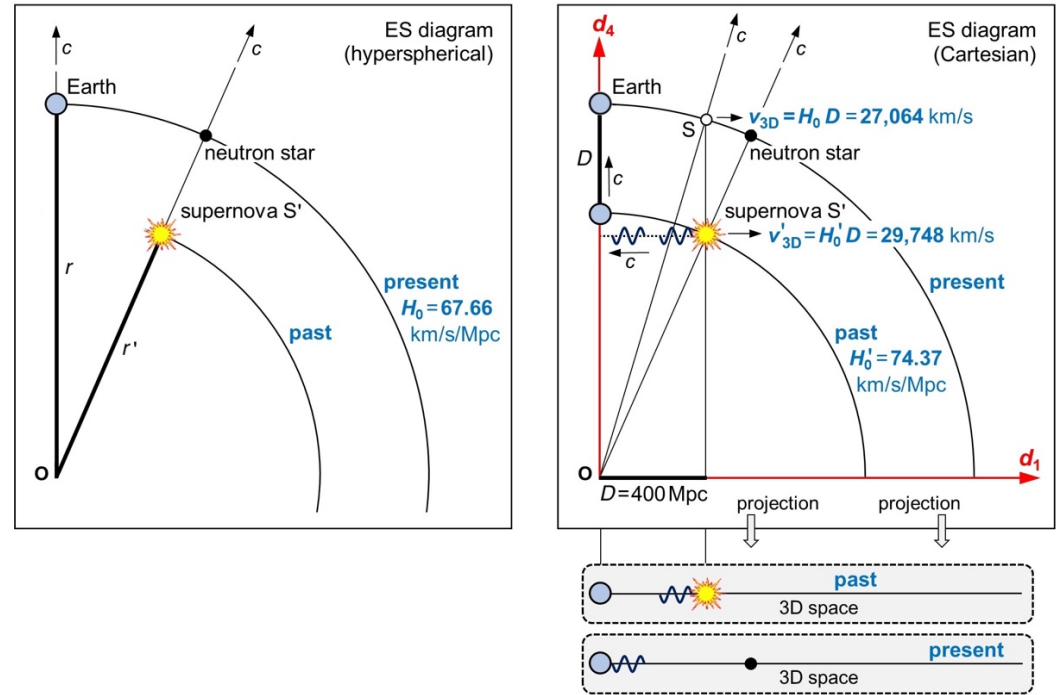

Figure 5. ES diagrams for team B's calculation of the Hubble constant. The location of the Big Bang serves as the origin O. **Left:** We suppose that 67.66 km/s/Mpc is the correct value of today's Hubble constant H_0 (present). A supernova S' occurred in the past when the radius r' of the hypersurface 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).

A short calculation confirms: For $D = 400$ kpc, team B's Hubble constant H'_0 would deviate from team A's Hubble constant H_0 by only 0.007 percent. Yet for distances up to 500 Mpc, team B's Hubble constant is *on average* (all $0 < D < 500$ Mpc taken into account) 8 to 9 percent higher than team A's Hubble constant. So, we advise team B to improve its value of H_0 by eliminating the systematic error in the redshift measurement. Team B can easily do so by adjusting the measured speed of the past v'_{3D} to today's actual speed v_{3D}. The equation for the correct adjustment is derived 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 receding galaxies in ER.* It isn't due to an expanding space in GR. Since team B is calculating a Hubble constant H'_0 of the past, we do prefer the method of team A: $H_0 \approx 67 - 68$ km/s/Mpc. If we assume that the hypersurface has been expanding uniformly at the speed c, the age τ of today's universe is equal to $1/H_0$. In this case, its age isn't 13.8 billion years [25] as claimed by the Lambda-CDM model, but 14.5 billion years. The adjusted age is in agreement with the observation that there are stars out there as old as 14.5 billion years [26].

In hyperspherical coordinates, there is no motion within the hypersurface. For this reason, the path of the supernova's light can't be seen in Fig. 5 left. Only in Cartesian ES coordinates (Fig. 5 top right) can we draw the light's path horizontally as we did in Fig. 3 top right. By projecting these Cartesian ES coordinates to an observer's 3D space do we see his reality (Fig. 5 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 stretched by expanding space. So, stretching occurs passively. 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 our model, the moment τ_s (when a supernova occurs) is very significant, but the timespan $\Delta\tau$ (during which light is traveling to Earth) is irrelevant. The farther τ_s is in the past, the higher are the Hubble constant H_0', the recession speed v_{3D}', and the redshift parameter z'. The wavelength of the supernova's light is initially redshifted by the Doppler effect. During its journey to Earth, the parameter z' remains constant. In ER, there is no expansion of space! As discussed in Sect. 5.4, ES can't be deformed. *In GR, space itself is expanding. In ER, a hypersurface is expanding in ES.* The hypersurface isn't expanding space, but energy receding from the origin O. 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.

5.10. Solving the Mystery of Dark Energy

In the CDM model of cosmology, space is expanding in order to explain the distance-dependent recession of galaxies. The CDM model has been extended to the Lambda-CDM model, where "Lambda" is the cosmological constant. Cosmologists are now favoring *an accelerated expansion* [27,28] over a uniform expansion of space. This is because measured recession speeds v_{3D} deviate from values predicted by Eq. (19) if H_0 is considered an averaged constant. The deviations increase with distance D and are compensated by assuming an accelerated expansion of space. An acceleration would stretch the wavelength even more and thus increase v_{3D} 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, the parameter H_0' from every past is higher than today's value H_0. 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 Fig. 5 right helps us to 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'. If the ES geometry is unknown, the too-high redshifts can only be explained by an accelerated expansion of space. Now that we know about the ES geometry, we can attribute the higher redshifts to measuring data from the past.

Any expansion of space is virtual. All that we ask for is to apply Occam's razor even if a Nobel Prize was given "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae" [29]. We claim that cosmology has been misled by Einstein time and GR. ***Expansion of space is a redundant concept.***

The term "dark energy" [30] was coined to come up with a cause for an accelerated expansion of space. We gave strong evidence that there isn't any expansion of space. ***So, dark energy is a redundant concept, too.*** It has never been observed anyway. The hypersurface isn't driven by dark energy, but by intrinsic energy: Radial momentum provided by the Big Bang drives all energy away from the origin O.

There are huge differences in the meaning of the Big Bang, universe, space, and time (Tab. 1). 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. In the Lambda-CDM model, spacetime is finite and deformable. In our model, spacetime is infinite and non-deformable. In the Lambda-CDM model, time is "what I read on my watch" (definition attributed to Albert Einstein). In our model, time is radial distance from an origin O in ES divided by the speed of light.

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 calculations 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.
Spacetime is finite and deformable.	Spacetime is infinite and non-deformable.
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 driven by dark energy.	3D hypersurface is driven by radial momentum.
Space itself is expanding.	3D hypersurface is expanding in spacetime.
Time is "what I read on my watch". (Einstein)	Time is radial distance r from O divided by c.
GR isn't compatible with quantum mechanics.	ER is compatible with quantum mechanics.

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

5.11. 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 MS, an object can't be both at once because waves distribute energy in space over time, while the energy of particles is localized in space at a given time. This is why we added our third postulate: All energy is "wavematter" (electromagnetic wave packet and matter in one). By combining our new concepts of distance and wavematter, we now demonstrate: *Waves and particles are actually the same thing (energy), but seen from two perspectives.*

Fig. 6 illustrates in Cartesian ES coordinates what our new concept of wavematter is all about. If I observe a wavematter (we call it the "external view"), that 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 that wavematter is propagating and oscillating: *I deem it wave.*
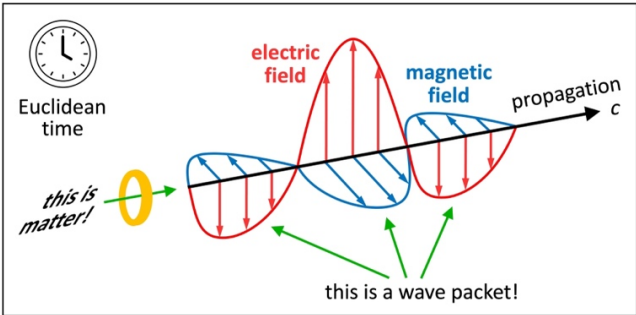

Figure 6. Concept of wavematter in Cartesian ES coordinates. Artwork illustrating how the same object can be deemed wave or matter. Wavematter comes in four orthogonal dimensions: propagation, electric field, magnetic field, and Euclidean time. Each wavematter deems itself matter at rest (internal or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

From its own perspective (we call it the "internal view"), that wavematter propagates in its axis d_4' at the speed c. Yet because of length contraction at the speed c, the axis d_4' (its flow of time) disappears for that wavematter. So, its own propagating and oscillating disappears for itself: *It deems itself matter at rest.* It still observes other objects propagating and oscillating in its 3D space since it keeps on feeling Euclidean time, while it is invisibly propagating in its axis d_4'. We thus conclude that there is an external view and an internal (in-flight) view of each wavematter. In SR and GR, there is no internal view of a photon because there is no reference frame moving at the speed c.

"Wavematter" isn't just a new word for the wave–particle duality, but a generalized concept of energy disclosing *why* there is wave–particle duality in an observer's 3D space. Someone may argue that our concept of wavematter would only take electromagnetic interaction into account. We agree that this interaction is special because it is directly related to the speed c. Yet we claim that all forces (electromagnetic force, weak force, strong force, gravitation) relate to a 4D rotation of wavematters in ES and a projection to an observer's 3D space. We already proved this claim for electrodynamics in Sect. 4 and for gravitation in Sect 5.5. We encourage colleagues to demonstrate that weak force and strong force, too, relate to a 4D rotation and a projection to 3D space.

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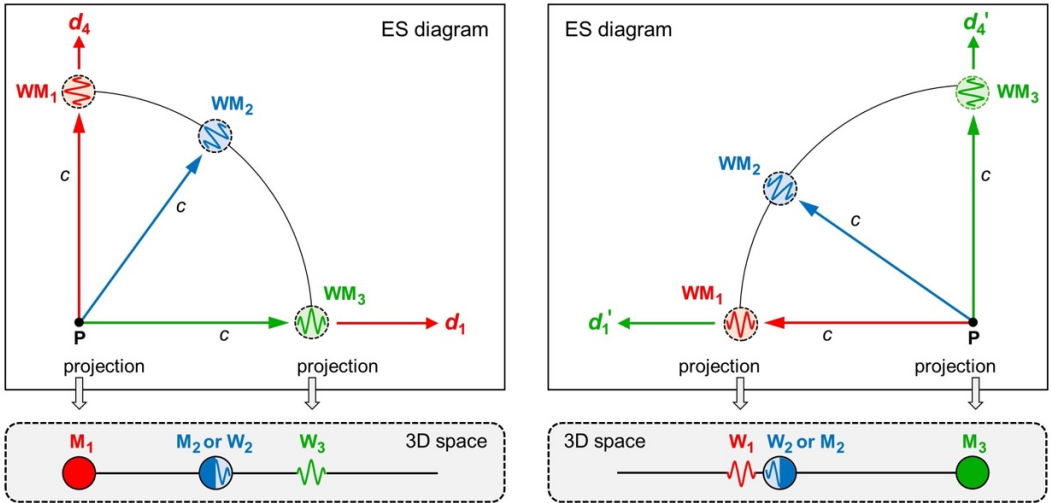

Figure 7. ES diagrams and 3D projections for three wavematters. **Top left:** ES in the coordinates d_1, d_2, d_3, d_4. WM_1 moves in d_4. **Top right:** ES in the coordinates d_1', d_2', d_3', d_4'. WM_3 moves in d_4'. **Bottom left:** Projection to WM_1's 3D space. WM_1 deems itself matter (M_1) and WM_3 wave (W_3). **Bottom right:** Projection to WM_3's 3D space. WM_3 deems itself matter (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 two 3D spaces of WM_1 and WM_3. Because 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). WM_3 likewise deems WM_1 wave (W_1).

And what is WM_2 deemed by WM_1 and WM_3? For the answer, we split WM_2's 4D motion into a motion parallel to WM_1's motion (here WM_1 is viewing WM_2 internally) and a motion orthogonal to WM_1's motion (here WM_1 is viewing WM_2 externally). That is to say: WM_1 can deem WM_2 either matter (M_2) or wave (W_2). WM_3 can likewise deem WM_2 either matter (M_2) or wave (W_2).

The secret to understanding our new concepts "distance" and "wavematter" is all in Fig. 7. Here we see how they go hand in hand: We claim the symmetry of all four Cartesian coordinates in ES and—on top of that—the symmetry of 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, energy in a propagating wave "condenses" to mass in matter at rest.

In ER, all wavematters are treated alike at once. Only in an observer's 3D space is a wavematter deemed wave or matter. In SR and GR, there is no such superordinate frame of reference in which all objects could be treated alike at once. It is the same asymmetry that we encountered in Fig. 1 top, where the two rockets aren't treated alike at once. This obvious shortcoming is due to the fact that Einstein time is egocentric. Only in ER (Fig. 1 center) are both rockets treated alike at once.

With all this insight, we are now prepared to bring light into the concept "photon". It actually stems from a misinterpretation of the wave–particle duality. The term "photon" was coined to explain this duality from the perspective of an observer, that is, from just one perspective: An observer can—depending on the experiment—confirm that electromagnetic radiation is either wave or photon. Yet the wave–particle duality is a matter of two perspectives. In ER, each wavematter (each photon, too) has a perspective of its own. We repeat one of our statements from above, but we now replace "matter" with "particle": *What I deem wave, deems itself particle.* Up next, we will break the spell on the wave–particle duality in two of its flagship experiments: (1) the double-slit experiment and (2) the outer photoelectric effect.

In a double-slit experiment, an observer detects coherent waves passing through a double-slit and producing 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 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.* Experiments with low-noise video cameras have also been performed [32]. The results confirm our theory: There is interference of waves if photons aren't tracked. Yet once we focus *on the internal view* of each wavematter ("Which CCD pixel will detect me?"), it behaves like a particle.

The outer photoelectric effect is quite different. Of course, we can externally witness how one photon is releasing 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 its energy exceeds the binding energy of an electron is that electron released. Hence, we *must* interpret this experiment from the internal view of each wavematter. Here its view is crucial! It behaves like a particle, which we nowadays call "photon".

The wave–particle duality is also observed in matter, such as electrons [33]. How can electrons behave like waves in a double-slit experiment? According to our third postulate, *all energy* is wavematter. So, electrons are wavematter, too. From the internal view (which is my view if the electrons are slow), electrons are particles: "Which slit will I go through?" From the external view (which is my view if the electrons are fast), electrons are waves. In ES, all wavematters are moving at the speed of light. In my 3D space, it all depends on the swing angle whether I deem a wavematter wave or matter. Fig. 7 even tells us why I deem macroscopic wavematters matter: Their speed in my 3D space is low compared with the speed of light thus favoring the internal view. This argument is a justification for drawing solid rockets and celestial bodies in our ES diagrams.

5.12. Solving the Mystery of Quantum Entanglement

The term "entanglement" [34] was coined by Erwin Schrödinger when he published his comment on the Einstein–Podolsky–Rosen paradox [35]. 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 [36]. 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 [37–39]. 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. Fig. 8 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 one wavematter is moving in the axis d_4. The other wavematter is moving in the direction of $-d_4$. If they are observed by a third wavematter in its 3D space spanned by d_1', d_2', d_3', they are deemed two objects, especially if they are already far away from each other. That third wavematter just can't understand how the entangled wavematters can communicate with each other in no time. This is again the external view.
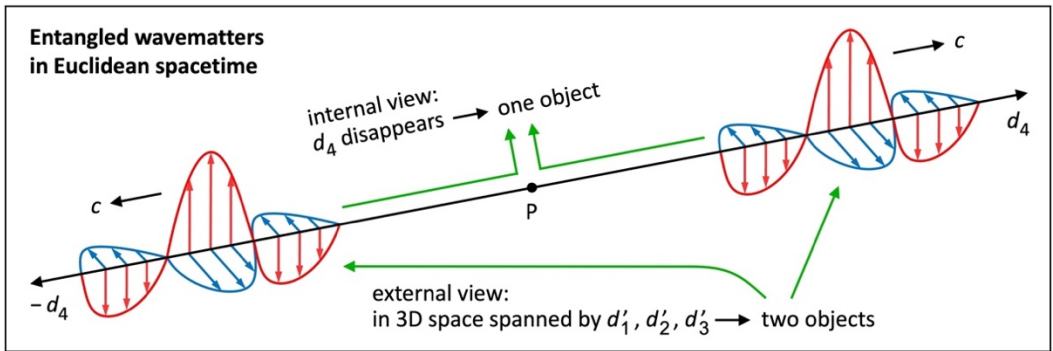

Figure 8. Quantum entanglement in ES. Artwork illustrating internal view and external view. For each displayed wavematter (internal view), the axis d_4 disappears because of length contraction. It deems its twin and itself one object. For a third wavematter that isn't moving in the direction of d_4 (external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

And here comes the internal (in-flight) view in ES: For each entangled wavematter in Fig. 8, 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 strong evidence that everything is moving through ES at the speed c. Our solution to entanglement isn't limited to photons. According to our first postulate, all energy is moving through ES at the speed c. So, electrons or atoms can be entangled, too. They are moving 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.*

5.13. 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, that energy is moving by itself. Einstein's physics can't explain how that 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 whose 4D motion swings by an angle of 90° into an observer's 3D space—and that energy is able to speed off at once. *In absorption,* a photon is spontaneously absorbed by an atom. Einstein'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 the photon's energy. Similar arguments apply for *pair production* and *annihilation* if photons are involved. Spontaneity is another clue that everything is moving through ES at the speed of light.

6. Conclusions

All attempts to unify GR and quantum mechanics have failed miserably. In Sects. 5.1 through 5.13, Euclidean time has solved mysteries that Einstein time either didn't solve—or that it has solved, but with 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 work: *As ER outperforms SR and GR, Occam's razor knocks out Einstein time.* Only Euclidean time enables us to glimpse behind the curtain of the universe. It is ER, and not GR, that unifies with quantum mechanics.

Many people believe that SR and GR are two of the greatest achievements of physics and have been confirmed many times over. Here we proved that they have a flawed concept of time. SR and GR work very well, but only as long as we describe the world on and close to Earth. 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, and not for SR or GR. We campaign for ER as it penetrates to a much 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.

We solved 13 mysteries of physics: (1) time, (2) time's arrow, (3) mc^2, (4) CMB, (5) gravitational time dilation, (6) Hubble's law, (7) flat universe, (8) cosmic inflation, (9) the Hubble constant, (10) dark energy, (11) the wave–particle duality, (12) quantum entanglement, and (13) spontaneity. These 13 solutions can be considered 13 proofs of ER. It was to our advantage that we, as non-cosmologists, aren't dazzled by SR and GR. *For quantum leaps in understanding, we must keep on questioning concepts.* Einstein sacrificed the absoluteness of space and time. We sacrifice the absoluteness of wave 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. ☺

Textbooks of physics must be revised to account for our three new concepts of time, distance, and energy: (1) There is absolute time. (2) Spatial and temporal distance are not two, but one [40]. (3) Wave and matter are not two, but one. We explained our three 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 this beauty, you first need to give yourself a little push—by accepting that reality is the projection of a 4D manifold. It isn't by chance that we solved 13 mysteries all at once. Only a Theory of Everything can do so. Yet be fair and don't expect us to address all of physics, as one editor did. We welcome you to join us in a paradigm shift! Hopefully, we contribute to an improved 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, contributed the concepts "distance" and "wavematter", and unified ER with quantum mechanics. He also drafted the report. Siegfried taught physics and math at the Waldorf School in Darmstadt, Germany. He contributed that Minkowski diagrams aren't in line with experimental physics and solved the Hubble constant. Everything else was solved together.

Conflict of Interest: The authors have no competing interests to declare.

Data availability statement: All data that support the findings of this study are included within the article.

References

1. Einstein A 1905 Zur Elektrodynamik bewegter Körper *Ann. Phys.* **17** 891–921
2. Minkowski H 1910 Die Grundgleichungen für die elektromagnetischen Vorgänge in bewegten Körpern *Math. Ann.* **68** 472–525
3. Einstein A 1916 Die Grundlage der allgemeinen Relativitätstheorie *Ann. Phys.* **49** 769–822
4. Rossi B and Hall D B 1941 Variation of the rate of decay of mesotrons with momentum *Phys. Rev.* **59** 223–229
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 *Phil. Trans. R. Soc. London* A **220** 291–333
6. Peskin M E and Schroeder D V 1995 *An Introduction to Quantum Field Theory* (Boulder: Westview Press)
7. Popper K 1989 *Logik der Forschung* (Tübingen: Mohr)
8. Montanus J M C 1991 Special relativity in an absolute Euclidean space-time *Phys. Essays* **4,** 350–356
9. Montanus J M C 2001 Proper-time formulation of relativistic dynamics *Found. Phys.* **31** 1357–1400
10. Almeida J B 2001 An alternative to Minkowski space-time (arXiv: gr-qc/0104029)
11. Gersten A 2003 Euclidean special relativity *Found. Phys.* **33** 1237–1251
12. van Linden R F J 2007 Dimensions in special relativity theory *Galilean Electrodynamics* **18,** 12–18
13. Pereira M 2017 The hypergeometrical universe (available at: http://www.worldscientificnews.com/wp-content/uploads/2017/07/WSN-82-2017-1-96-1.pdf) (Accessed 15 December 2022)
14. Machotka R 2018 Euclidean model of space and time *J. Mod. Phys.* **9** 1215–1249
15. Kant I 1781 *Kritik der reinen Vernunft* (Riga: Hartknoch)
16. Rovelli C 2018 *The Order of Time* (London: Allen Lane)
17. Weyl H 1928 *Gruppentheorie und Quantenmechanik* (Leipzig: Hirzel) Chap. III, § 8c
18. Penzias A A and Wilson R W 1965 A measurement of excess antenna temperature at 4080 Mc/s *Astrophys. J.* **142** 419–421
19. Padmanabhan T 1993 *Structure Formation in the Universe* (Cambridge: Cambridge University Press)
20. Hubble E 1929 A relation between distance and radial velocity among extra-galactic nebulae *Proc. Nat. Acad. Sci. USA* **15** 168–173
21. Linde A 1990 *Inflation and Quantum Cosmology* (Boston: Academic Press)
22. Guth A H 1997 *The Inflationary Universe* (Reading: Perseus Books)
23. Aghanim N, Akrami Y, Ashdown M et al. 2021 Planck 2018 results. VI. Cosmological parameters (arXiv: 1807.06209)
24. Riess A G, Casertano S, Yuan W et al. 2018 Milky Way Cepheid standards for measuring cosmic distances and application to Gaia DR2: Implications for the Hubble constant (arXiv: 1804.10655)
25. Choi S K, Hasselfield M, Ho S-P P et al. 2020 The Atacama Cosmology Telescope: A measurement of the cosmic microwave background power spectra at 98 and 150 GHz (arXiv: 2007.07289)
26. Bond H E, Nelan E P, VandenBerg D A et al. 2013 HD 140283: A star in the solar neighborhood that formed shortly after the Big Bang (arXiv: 1302.3180)
27. Perlmutter S, Aldering G, Goldhaber G et al. 1998 Measurements of Ω and Λ from 42 high-redshift supernovae (arXiv: astro-ph/9812133)
28. Riess A G, Filippenko A V, Challis P et al. 1998 Observational evidence from supernovae for an accelerating universe and a cosmological constant (arXiv: astro-ph/9805201)
29. The Nobel Prize 2011 (available at: https://www.nobelprize.org/prizes/physics/2011/summary/) (Accessed 15 December 2022)
30. Turner M S 1998 Dark matter and dark energy in the universe (arXiv: astro-ph/9811454)
31. Heisenberg W 1969 *Der Teil und das Ganze* (Munich: Piper)
32. Aspden R S, Padgett M J and Spalding G C 2016 Video recording true single-photon double-slit interference *Am. J. Phys.* **84** 671–677
33. Jönsson C 1961 Elektroneninterferenzen an mehreren künstlich hergestellten Feinspalten *Z. Phys.* **161** 454–474
34. Schrödinger E 1935 Die gegenwärtige Situation in der Quantenmechanik *Die Naturwissenschaften* **23** 807–849
35. Einstein A, Podolsky B and Rosen N 1935 Can quantum-mechanical description of physical reality be considered complete? *Phys. Rev.* **47** 777–780
36. Bell J S 1964 On the Einstein Podolsky Rosen paradox *Physics* **1** 195–200
37. Freedman S J and Clauser J F 1972 Experimental test of local hidden-variable theories *Phys. Rev. Lett.* **28** 938–941
38. Aspect A, Dalibard J and Roger G 1982 Experimental test of Bell's inequalities using time-varying analyzers *Phys. Rev. Lett.* **49** 1804–1807
39. Bouwmeester D, Pan J-W, Mattle K et al. 1997 Experimental quantum teleportation *Nature* **390** 575–579
40. Niemz M H 2020 *Seeing Our World Through Different Eyes* (Eugene: Wipf and Stock). Niemz M H 2020 *Die Welt mit anderen Augen sehen* (Gütersloh: Gütersloher Verlagshaus)