From Signal To Atom To Universe - Shelving Plain and Curved Space-Time Geometry in Favor of Examining the Physical Processes They Have Been Concealing *

Erik A. Cerwen*

**www.scienceandresearchdevelopmentinstitute.com*

Sep. 20, 2025

Abstract

The author's recent discovery that the Lorentz factor can be derived from the properties of a rotating dipole projecting an electric field transverse to its longitudinal axis of propagation with velocity c is pursued with the aim of investigating if there are more effects of relativistic space-time geometry that may instead be interpreted as plain physical processes. In the previous papers on the topic it was shown 1) that the atomic absorption of a light signal can be interpreted as wave sweeps consistently with a rearranged form of Maxwell' relativistic field equations and 2) that the electron in response to the wave sweeps may act as if it exists in a non-local form comprising 'Stokes curl cells' arising by analogy with electric and magnetic curl at the nodes of the radiation. In the present paper the this theory is extended to time and mass. It is found that the clock of the rotating dipole, the signal, transmits an apparent shortened time to the absorbing particle which is compensated by the latter's clock going slower - a necessity in order to preserve phase coherence within the longitudinal and transverse components of the relativistic signal and the particle's own clock. Further, because of how angular momentum is constructed the time delay is prone to automatically give rise to an apparent increase of mass, in, and as interpreted by the measuring particle. Relativistic time is thus easy to reinterpret as a physical process - the particle measures its environment with its internal clock. Mass requires the derivation from the Bohr ground state of a velocity function of a line increment and a current. The line increment is a fraction of the Planck length and has a numerical value that agrees with the local Hubble

 Published on the Internet on Sep. 20, 2025. Citation: Shelving... Proceedings of www.scienceandresearchdevelopmentinstitute.com , Quantum Physics & Cosmology No. 39 (2020). Email: cerven@scienceandresearchdevelopmentinstitute.com NOTE: This series of papers of 25 years has been written without private or public funding purporting to be in the field of physics even though it is neither motivated by encryption, nor powerful lasers, nor nuclear fusion. Against this background the reader is free to pause from the bandwagon and bet on this occasion a sum of money *via* the author's indicated PayPal address at this site. The author's bet is that some of his most recent papers are judged somewhat better that some of the earlier ones. A lost bet; the reader says 'No, not so', will be considered paid by the author's purposed expenditures recirculating one way or another in the global economy. The individual reader accepting this bet will be considered an indication of approval of the kind of activity in a differentiated economy that writing these kind of papers represents. Bettors' electronic addresses & identities will not be taken out of the money mediator's database.

apparent expansion rate so that its square can be interpreted as a high energy environment providing mass (eqv. energy) to the particles, which is quantitatively exemplified based on the resonance bosons and the electron. The squared current is interpreted as the frequency of a wave. Hence, the squared line increment (the mass, that is) and the current (frequency) have the effect of a velocity substituting for the usual relativistic velocity in the Lorentz factor. In this context and previous abstract theory, e.g. [9], building on the author's idea that the universe has the same geometry as the atom, the visible, apparently receding mass of the universe is sustained by non-local mass similarly to a lasing atom.

1 Introduction

In the most recent papers in this series [1] [2] [3] it was shown how the Lorentz factor can be derived by considering a rotating dipole that projects an internal electric field in the transverse direction while propagating forward at the speed of light. The ratio of the dipole's radius to its velocity of rotation was obtained geometrically and found to accommodate not only the electromagnetic radiation but also the Bohr hydrogen atom in any of its excitation states. This finding hints at an explanation of the so called wave-particle duality of light and indicates that the origin of 'relativistic' effects should be sought in concrete physical processes rather than plain space-time geometry. Especially the failure to observe the so called Lorentz-Fitzgerald length contraction in theory [4] [5] as well as experiment [6] (although the topic is still debated, cf. [7]) gives an impetus to searching for alternative explanations of relativistic effects since that length contraction is a founding element of special relativity theory, preceding all subsequent adaptations to it. Special relativity can also be criticized on the grounds that it does not describe non-local *versus* local observers in signal transmission, it assumes instead that everything can be placed in eternal local coordinates, into infinity, and that signals can be sent back and forth to precise remote places in the universe as if the universe were a static crystal. Also the instantaneous decoherence of entangled states of light over vast distances is difficult to understand based on special relativity theory (SR) and its limiting velocity of light.

In the present series of papers the length contraction is avoided by letting a local observer of linear momentum interact *via* Lorentz transformations with a non-local observer who only measures time [8] [9] whereby time is perpendicular to length in one dimension. Here, non-locality is achieved by the local observer's inability to measure other than the 1-D spatial linear momentum (axial or straight) in a time interval of observation while ignoring everything else in the universe. The 1-D observer is, essentially, a particle. This geometry accommodates a rearranged form of the relativistic version of Maxwell's equation of the electric field of propagating polarized light in terms of local and non-local observers [2] [10] and allows the signal absorption to be followed in the form of wave sweeps of its phases [2] . It is well known that some experiments, like the scattering of X-rays off metal and the 'photoelectric effect' can be explained in terms of particles having classical momentum but such a photon particle idea is counterintuitive in most cases of refraction, which tends to bend energetic radiation more than less energetic radiation. This latter observation can, however, be perfectly understood in terms of the medium interacting with the wave proportionally to the number of wavelengths or number of rotations of a dipole per time interval thus hinting at a role for wave sweeps in refraction. Then, upon re-examining the photon idea it is recalled that the ionization energy of hydrogen in the ground state sets the electron free precisely when a quarter of a wavelength of the Lyman radiation at 91.1 nm equals half an electron-orbit in terms of time [1]. This can hardly be a coincidence since a quarter a wavelength is precisely what embodies the radiation's momentum in one direction and half an electron-orbit is precisely the optimal time for an interaction with such a wave, neither more nor less. Therefore, the possibility can not be excluded that wave-sweeps are the ultimate cause of the apparent particulate nature of hard radiation in addition to the recent evidence that the absorption between energy levels can be described in terms of such wave-sweeps. As mentioned above, advantages of the latter theory [1] [2] include that one can get an intuitive understanding of the wave-particle duality of radiation, one can follow the absorption in the phases of the wave and calculate the size preferences of the rotating dipole, possibly a 'photon'. This represents an advantage in comparison with previous theory in which the 'photon' is conceived as a non-material carrier of quantized energy that *incognito* (no mass, that is) transfers mechanical momentum when interacting with matter or magically rises and lowers the electron's 'energy levels'.

These discoveries set the stage for the present paper; reinterpreting the 'space-time' of relativity theory in terms of concrete physical processes taking place in the signal-receiving particle.

2 Length and Time.

In special relativity theory the length contraction of an approaching measuring rod, the slowing down of clocks in the approaching object, the apparent increase of 'energy' and mass of the approaching object, and the frequency transformations due to the time dilatation are the founding elements upon which the rest of the theory is based.

In this now turned 'classical' theory the pillars are the transformations of length and time. The length transformation is written[1]

$$x' = \frac{x \pm vt}{\sqrt{1-\frac{v^2}{c^2}}} \longrightarrow x'\sqrt{1-\frac{v^2}{c^2}} + vt = x \tag{1}$$

where the primed coordinate represents the observer or object who recedes or approaches with velocity v in the direction of observation seen by the unprimed observer. Here, x and x' are the x-coordinates along the line of sight measured by the observers. The numerator to the left, $x \pm vt$ reflects the assumption that the static distance, x is dislocated proportionally to the relative velocity. The term in square roots to the right is the so called 'Lorentz-Fitzgerald contraction' (of length) which is a mathematical operation introduced in the early 20:th century in order to describe that the velocity of light (in vacuum or air) is the same in all direction (irrespective of Earth's rotation etc.) so light does not seem to require any medium for propagating. As can be seen in Eq. 1 (its right-side version) the Lorentz contraction is ascribed to the moving object (left) as measured by the stationary observer (right). However, the references cited in in the introduction show that the Lorentz contraction does not take place and this is troublesome for relativity theory since it is the archetype of all 'relativistic effects', underpinning all its measures of volume.

The purpose and venture of the present paper is to show that, contrary to the established view, relativistic effects occur, not in the measured object-particle or through some embedding geometry but in the measuring particle while processing the signal. Following up on [1], [2] [3] the signal is interpreted as a rotating dipole projecting onto (read: equivalent of) an electromagnetic wave and the

[1]many textbooks are available, this paper follows [11] which accounts visibly for the velocity of light, c.

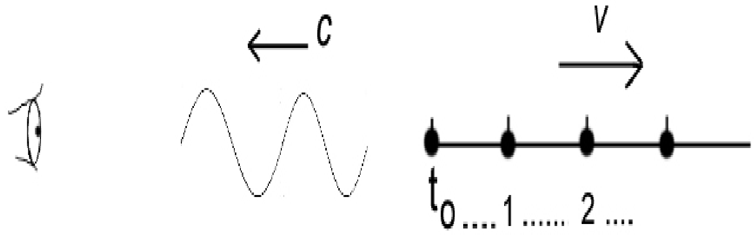

Figure 1: An observer (left) measuring time *via* a signal (c) coming from a periodic event taking place from t_0 to t_1 in a particle moving rightwards as described in the main text.

dipole's rotation adds velocity v in its one (say, upper) half orbit and subtracts velocity v in its other (lower) half orbit. Since the Lorentz factor can be written $(\sqrt{c^2/c^2 - v^2/c^2})^{-1} \Rightarrow (c+v)(c-v)/c^2 = (c^2 - v^2)/c^2$ the right side version of Eq. 1 is written

$$x'\sqrt{[(c^2 - v^2)]} = \sqrt{[c^2]}(x - vt) \tag{2}$$

There are now two observers connected *via* a linear (Galilean) length transformation, $-vt$, and the one to the left above has taken over the nonlinear 'relativistic' effect on length. The moving particle (observer) to the right above emits a light signal c^2 which takes the emitter's frame of observation with its coordinate x moved linearly with velocity v all the way to the recipient, the observer to the left. During signal processing the rotation of the signal, $(c+v)(c-v)$ is accounted for by the recipient as described in [1] and [2]. This eliminates the now [6] disproved length contraction that has been so much discussed in the scientific literature and textbooks[2]. Eq. 2 instead allows the recipient of the signal to do the job of straightening out a relativistic distortion such as to make the signal equivalent of the form it had when emitted from the sender, an idea that also is relevant to cosmological redshift [12]. Proceeding from [1] one is now faced with the interesting task of identifying the true physical processes behind the purported geometric-relativistic effects in measuring time and matter.

As for the case of time, consider the particle moving from $t = 0$ to $t = 1$ in Fig. 1 and the time t_1 it displays to the stationary observer (at left) *via* some periodic internal process. The time t_1 seen by the observer will be delayed first by the factor x/c because of the time x/c it would take for a plain signal from a stationary particle to travel leftwards and then by an additional factor v/c because of the particles rightward velocity, which is counted as a fraction of the maximal velocity c. This results in the linear transformation

$$t' = t + \frac{v}{c}\,\frac{x}{c}. \tag{3}$$

The signal is then carried leftwards on a light ray having properties of propagation $c = \sqrt{1/\mu_0\epsilon_0}$ in the emitting particles rest frame (right side below) until it reaches the observer where it displays its 'relativistic' distortion, which is, in this theory, a physical rotation $\sqrt{c^2 - v^2}$. This is expressed by

$$t'\sqrt{c^2 - v^2} = c^2(t + \frac{v}{c}\,\frac{x}{c}), \tag{4}$$

mathematically equivalent of the classical relativistic time transformation,

[2]...provoking 'thought experiments' such as the velocity needed to park a car in a too short garage...

$$t' = \frac{t + \frac{v}{c^2}\ x}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{5}$$

with its time interval written

$$t'\sqrt{c^2 - v^2} = \sqrt{c^2}t \tag{6}$$

but it has a concrete physical meaning. Namely, Eq. 4 offers the observer - a signal-absorbing particle to process the signal, for example as in [2] and [1]. The information thus gathered (previously hidden in 'relativistic space-time') has practical applications since it provides a testable framework for experiments targeting in detail the orbiting and transitioning atomic electron in the context of the phases of the signal, and by inference any other similar particle context as discussed in [1] and [2].

Examining the special-relativistic transformation of frequency shows the conceptual differences between previous theory and the present one. First the classical description which assumes the relativistic effects are due to space-time geometry. Here, the primed observer's emitted frequency is measured by the stationary un-primed one:

$$\nu = \nu' \frac{\sqrt{1 - \frac{v^2}{c^2}}}{1 - \frac{v}{c}\ cos\phi} \Longrightarrow \nu = \underbrace{\nu' \frac{\sqrt{1 - \frac{v^2}{c^2}}}{1 \pm \frac{v}{c}}}_{longitudinal\ velocity} ; \nu = \underbrace{\nu' \sqrt{1 - \frac{v^2}{c^2}}}_{transverse\ velocity} \tag{7}$$

In this classical case 'relativistic' effects are ascribed to the 'geometry' which is claimed to be more notable with longitudinal relativistic velocities compared to transverse ones. In the present theory, however, physical processes (involving a rotation at the wave-matter interface [1] and [2]) are behind relativistic effects (period, $\tau = \nu^{-1}$):

$$\frac{1}{\tau\sqrt{c^2 - v^2}} = \frac{1}{\tau' c(1 \pm \frac{v}{c})} \Leftrightarrow \tau\sqrt{c^2 - v^2} = \tau' c(1 \pm \frac{v}{c}) \tag{8}$$

where the right side is just the time-transformation of Eq. 4 once again. Everything but the rotation remains linear since the emitted signal propagates in the emitter's rest frame all the way to the absorbing particle and the 'relativistic effect' does not take place until absorption of the signal. Hence, from Eq. 7 and Eq. 8

$$\nu = \nu' \frac{\sqrt{1 - \frac{v^2}{c^2}}}{1 \pm \frac{v}{c}} \underbrace{\Longleftrightarrow}_{wrong} \underbrace{\quad \neq \quad}_{right} \nu = \frac{1}{\tau\sqrt{c^2 - v^2}} = \frac{1}{\tau' c(1 \pm \frac{v}{c})} \tag{9}$$

it is evident that one can not infer in this case from the mathematical equivalence that the underlying physical processes are equivalent.

When examining the factor $\sqrt{c^2 - v^2}$ which acts on time in Eq. 4 and on inverted time in Eq. 9 it becomes clear in the following that it has precisely the expected physical origin. Consider first the factors that act on the measuring observer's time in Eq. 4 as sketched in Fig. 2. The factor $\sqrt{1 - v^2}$ actually does the opposite of a 'time dilatation', it shortens the time. This factor has the form of an equation of the circle and its effect on time is equivalent of projecting the circle onto the vertical (y-) axis in the graph of Fig. 2. The factor is ascribed to the signal which is interpreted as a rotating dipole projecting an electric field onto its center as in [1] and [2]. The physics of this time contraction

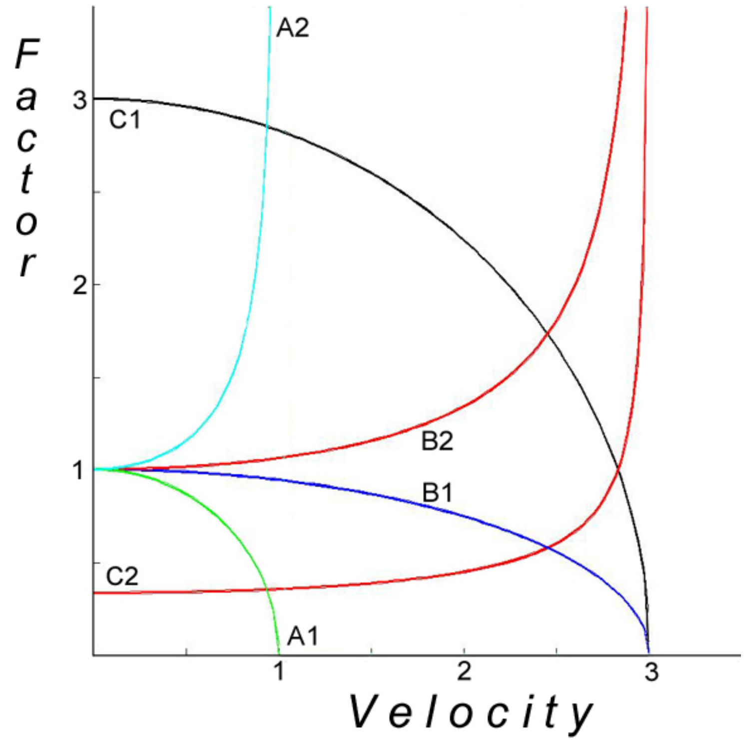

Figure 2: Illustration of the effects of the Lorentz factor and its factorized components on the time of a moving particle as measured by a stationary observer-particle (cf. Fig. 1, Eqs. 4 and 5). The curve A1 represents $y = \sqrt{1 - x^2}$, the equation of a unit circle, A2 its inverse $y = 1/\sqrt{1 - x^2}$, B1 $y = \sqrt{9 - x^2}/3$, B2 is the latter's inverse $y = 3/\sqrt{9 - x^2}$, C1 represents $y = \sqrt{9 - x^2}$ and C2 $y = 1/\sqrt{9 - x^2}$. The curves labeled '1' affect the signal and those labeled '2' show how the signal-absorbing particle compensates the effects of factors labeled '1'. The factors labeled '2' are all 'time dilatations' taking place in the measuring particle and not in the geometry *per se*, and these may be relayed onto a 3:rd observer.

is interpreted as in Fig. 3: The signal's internal clock, equivalent of its frequency, projects on the signal's time axis, which is parallel to its axis of propagation and scaled by its velocity c; $t = x/c$. The absorption takes place while the dipole rotates (equivalent of the electromagnetic field sweeping by) and requires a certain time to be effectuated. The working hypothesis is that the absorption relies on the forward rotation of the dipole (upper half in Fig. 3) which carries more momentum than the backward rotation of the same dipole. If the emitter moves with some velocity relative to the absorbing particle the time it takes to effectuate absorption will be shortened by the mere forward movement of the emitter's rest frame which carries the signal and this becomes notable only close to the velocity of light[3]. (The same applies whether the emitter recedes or approaches. Both cases generate a factor $+v$ and a factor $-v$ in the rotation). In other words, if the rotating dipole is like the hands on a clock it is evident that moving from t_2 to t_3 in the upper half of Fig. 3 will go faster as seen by the absorbing particle if the emitting particle and its rest frame including the signal moves leftwards. This may well involve velocities $v + c$ higher than c [4], however still staying causal around c not even necessarily trespassing the established dogmas since the signal absorption may also take place as a result of torque at the center of the dipole's rotation. As for the relativistic effect, the obvious logic is that if the signal's longitudinal clock goes faster the recipient's clock (a rotation too) must go slower in order to evade a phase mismatch when the two clocks jointly move on to the next transverse component of the radiation.

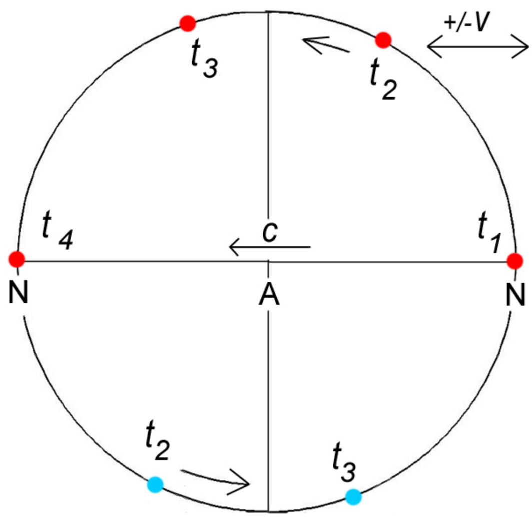

Figure 3. Illustration of half a wavelength of the electromagnetic radiation in the form of a rotating dipole (red dots = position of the positive (fraction of a) charge in subsequent points of time, t, blue dots = negative charge. N= the signal's node and A = its antinode. The signal propagates leftwards from an emitter to the right with velocity c to an absorbing particle to the left as in Fig. 1 while the emitting particle (not shown here) and its rest frame containing the signal moves with velocity v. The absorption starts at t_1 and reaches its maximal susceptibility to the approaching-receding velocity between t_2 and t_3. Note that a quarter of a wavelength is sufficient for signal absorption to take place. A quarter of a wavelength contains the forward momentum of the signal in its sole interacting wavelength period and subsequent wave periods are mute. This is different from the case of refraction where multiple wave periods interact with the medium causing more bending with increasing frequency.

[3]Since length and time are proportional and c is constant there is also a concomitant length contraction taking place. However, this length contraction is different from the "Lorentz-Fitzgerald contraction of relativity theory. The latter is a (now refuted [6]) mathematical construct which underpins various derived theoretical SR-constructs in involving volume

[4]perhaps a chilling statement for the inveterate relativist, never mind

In the previous papers [2] [1] it was shown that the electron is capable of counteracting this (relativistic) distortion in the signal by self rotating in the opposite direction. Analyzing how this happens led to the discovery of a pristine manifold of possible events and mechanisms at the sub-electron-cloud level [1]. It was originally hypothesized that the 'relativistic' effects on longitudinal and transverse components of the signal had to be different [13], invoking wave sweeps (instead of particle momenta) and the necessity of a mechanism of correction of this phase mismatch. This becomes rather obvious now by examining the rotations and velocities in Fig. 3, building on [2]. However it suffices to apply common sense without invoking geometrical 'relativity' and as a reward one gets an intuitive sense of the signal's 'wave-particle duality'.

In conclusion, it seems possible to understand the 'relativistic effects on length and time during signal absorption in terms of physical processes. This does not prove that SR is wrong since one may hypothesize that the signal absorption has adapted to its overall geometry[5]. Even if that were true one could argue that scientific endeavor should aim at increasing the accurate knowledge about the world rather than proving or disproving SR-GR. In the early days of SR the half life of muon decay striking the Earth was quoted as strong evidence supporting the idea that SR is a 'natural geometry' seemingly explaining relativistic 'time dilatation': Can the muon in its own rest frame know ahead of time that there is a Terrestrial observer who is going to measure it to have a certain velocity by counting the number of decay-surviving particles reaching the Earth's surface? The answer is likely 'no' and even though the measurements within errors seemed to support the idea there were uncertainties in the effect of Earth's atmosphere. Furthermore, the gravitation of the Earth causes time to go slower while the muons decay. This is now becoming known with molecular atomic clock-precision to be true. So, having dealt with space and time a safe rescue from the muon challenge will necessarily involve gravitation and mass.

3 Mass and Energy

A promising candidate for exploring if relativistic effects on mass can be ascribed to some concrete physical process is the equation (cf. [3] [2], the latter's Eq. 15 for derivation)

$$\alpha = \frac{1}{\mathbf{K}} \frac{\overline{\Delta q}^2 \mathbf{C^2}}{\pi^2 Amp^2} \;\Big(\iff \alpha c = \frac{c}{\mathbf{K}} \frac{\overline{\Delta q}^2 \mathbf{C^2}}{\pi^2 Amp^2}\Big) \tag{10}$$

applicable to the hydrogen atom in the ground state and

$$v = \frac{c}{\mathbf{K}} \frac{\overline{\Delta q}^2 \mathbf{C^2}}{\pi^2 Amp^2} \frac{a^2}{b^2} \tag{11}$$

for the general case, where $\mathbf{K}$ is a dimensional constant having value 7.4246×10^{-35}, α is the fine structure constant , $\overline{\Delta q}$ is a factor (fraction of) the Planck length having the numerical value 7.714×10^{-27} m

[5] The signal absorption process in the present series of papers is supported by a geometry different from SR i.a. in that one (non-local) observer can observe time only and not length [8] [9] [2]. This geometry applies to the particle and not its environment: Everything but the particle and its measuring linear momentum remains 'non-local'

(see e.g. [14] [15] or [16] for derivation), Amp is the SI-unit of electrical current and $\mathbf{C}$ is a numerical constant of value c in SI-units and a and b are factors that act on respectively $\overline{\Delta q}$ and the current. This equation has all the essential features discussed in the previous section on length and time. It contains the fine structure constant indicative of the electron's relativistic velocity in the hydrogen ground state, the equation's fraction of the Planck length is indicative of 'energy' alternatively mass and it also has two (semi-circular) currents like in Fig. 3. These striking similarities to the physical mechanisms behind 'relativistic effects' on length and time discussed in the previous section merit that each and every factor in Eqs. 10 - 11 is dissected and analyzed from all angles before proceeding to the physical mechanisms it may reveal.

First, an analysis of dimensions ($Amp = \mathcal{C}oulomb/sec$),

$$\left[\overline{\Delta q}^2\right] \; \left[\mathbf{C}\right] = \left[K\alpha\pi^2\right] \; \left[Amp^2\right] \;\Rightarrow\; \frac{m^2}{m^2\ s^2}\,(-) \quad = \quad (-)\,\frac{\mathcal{C}^2}{sec^2} \tag{12}$$

with $K = 1/4\pi\epsilon_0$ (from the fine structure constant defined as $\alpha = e^2/4\pi\epsilon_0\hbar c$) shows that the line increment, $\overline{\Delta q}$, is taken per unit length and unit (geometrized) time $(s)^6$, which is also the dimension of the apparent cosmological expansion.

Next, the hydrogen atom in its ground state is used to find a circular current (cf. Fig. 3) corresponding to its ionization energy, $E = h\nu = hc/91.1 \times 10^{-9}m = 2.18 \times 10^{-18}\ J = 13.6\ eV$. The relativistic case of Eq. 2 in ref. [1]; $V = 2\pi Rc/\lambda$, where V and R are the dipole's rotation velocity and radius of circulation respectively, is borrowed for the non-relativistic Eqs. 10 and 11. This is justified by the idea that the relativistic contribution happens at the moment of absorption, possibly directly *via* some kind of torque and it is certainly not a sustained velocity increment during signal propagation. R is a free variable but its most likely value is $\lambda/4$, which does not strain the dipole's circulation geometrically (cf. Fig. 3 and drawings in [1]) so the circulation velocity becomes $V = c\pi/2$ on the orbit of $2\pi R = 2\pi\lambda/4 = 143.1 \times 10^{-9}\ m$. Hence, the rotation frequency is $V/2\pi R = 3.291 \times 10^{15}\ sec^{-1} = 9.87 \times 10^{23}\ s^{-1}$. This agrees with the energy 13.6 eV. The charge carried by 13.6 eV is $e_\nu = 13.6 \times 1.6022 \times 10^{-19} = 2.179 \times 10^{-18}\ Coulomb$ so the current flowing in the rotating dipole of the ionizing radiation is $I_\nu = e_\nu \times V/r\pi R = 2.15 \times 10^6{}_{geom} = 0.00717 Amp_{SI}$. Summarizing the numbers above,

$$I_\nu = e_\nu \frac{V}{2\pi R}; \quad R = \lambda/4\ . \tag{13}$$

This current produces a magnetic moment of $\mathbf{m}_{geom} = I\pi R^2 = 3.90 \times 10^{-26}$ to which adds the extra torque and magnetic moment caused by relativistic receding or approaching velocities, everything ready to be handled by the constant $\mathbf{K}$ which is proportional to the magnetic permeability. It is thus possible to calculate some circular current equivalent of the signal and its relativistic distortion which links Eqs. 10 and 11 to electromagnetic radiation. As a consequence, the equation acquires a subtle beauty, while being so simple, accommodating everything that the world is made of; mass (energy), electromagnetic radiation and momentum, with space and time entering *via* the velocity.

The squared form of the current (frequency) as well as that of the line increment (mass-energy, see next paragraph) is conspicuous and well motivated. In the case of electromagnetic radiation there is, besides the circulation of charge discussed in the previous paragraph, an energetically equivalent circulation of magnetic charges forming a rotating magnetic dipole. These two currents cancel at

[6] non-standard notation *sec* is used for SI unit time

the nodes of the radiation which is also where they reach a maximum in spite of the node being 'dark'[7]. The nodes of the radiation with their maximum curl may be regarded as the site of the radiation's kinetic 'energy' while its potential energy resides in the antinodes[8]. On account of being 'dark' ((undetected, invisible) and accommodating the maximum of rotation the nodes are the site of the non-local observer in the present geometry [9] [10] [13]. The interpretation above of the composite magnetic and electric currents π^2 Amp^2 of Eqs. 10 and 11 is consistent with the appearance of a magnetic monopole, $ec/2\alpha$, in their derivation (cf. [2]) since this monopole must have a complement (the 'signal' was not used in the derivation of Eq. 10). It is therefore justified to substitute the two currents of Eq. 11 for the frequency of a wave-packet and factorize out Planck's constant from $\mathbf{K}$,

$$v = \frac{c}{\mathbf{K_2}} \frac{\overline{\Delta q}^2 \mathbf{C^2}}{h\nu}. \tag{14}$$

where K_2 is another constant.

As for the squared line increment in the numerator, several lines of evidence support regarding it as equivalent of mass-energy. First of all, it is a fraction of the Planck length squared (cf. [14] [15] or [16]) and the Planck constant is notoriously involved wherever there is 'energy'. Moving from energy to mass is routine in contemporary physics but the squared line increment factually enters into a stoichiometric relation with the resonance bosons and the Higgs particle [17], which have been implicated in matter creation in the early universe, reinforcing the notion in this series of papers that the line increment is equivalent of the local cosmological apparent line increment and corroborating the interpretation of its square as a 'mass' -term.

When addressing the concepts of time and mass it is unavoidable to take a cosmological perspective. Consider therefore the matter density of the universe, which is 0.049 in standard 'ΛCDM' cosmology [18] and compare to a universe that stretches to its relativistic horizon at radius r_u. Based on the squared line increment the latter has a density per circle segment of

$$\rho_u = {r_u}^2/(4\pi {r_u}^2) = 0.079 \ . \tag{15}$$

The numbers are close, leaving cosmology hypotheses aside. As for the age of the universe, the standard model claims $13.87 \pm 0.02 \times 10^9$ years whereas the linear universe favored here yields the number 13.7×10^9 (eqv. $1/H_0$) - both however, without addressing the nature of large-scale time or for how long the past has been reflected into the future without evaporating into nothingness (as judged from here)[9]. As evaluated in the previous section of this paper it is easier to get a grip on time at the particle level where inherent rotations provide a known natural clock:

In the geometry of the present series of papers the squared line increment can be interpreted as either angular momentum or action (energy $\times$ time). This arises from assigning a dimension (a 'frame

[7]A similar logic applies to the 'force' and 'counter-force' in classical physics the effect of which at equilibrium is limited to 'strain' within the material, which is not so easily detected by an external observer.

[8]This 'dark energy' has been on every physicist's desk for 150 years, still un-noticed, while the debate is ongoing about the other, mysterious, dark energy required for making standard cosmology compatible with observations.

[9]In the present series of papers the universe is modeled by analogy with the geometry of the atom whereby the local universe corresponds to the electron and the universe's relativistic horizon harbors mass corresponding to a non-local atomic nucleus seen from the rapidly rotating electron's perspective (cf. solar system). By consequence, the universe acquires a boundary.

signature', local or non-local) to the SI-units[10] (cf. e.g. p. 5 in [16] or [19]). The proportionality between the time and mass of a given particle is inherent in both these measures hinting at their identical relativistic transformations.

Hence, one has already found a clue to a concrete physical mechanism that may cause relativistic effects on mass. Especially the angular momentum is a robust platform compared to the vague concept of energy. It can easily be integrated into the rotations and counter-rotations (equivalent of clocks) described in the previous section. In this picture of relativistic effects the gist is that the rotations must be in phase and a perturbation of one of the rotations, typically the signal as modeled herein [2], must be countered by the other rotations that are involved in the physical process in question (signal absorption) so that all rotations are brought into phase again. Navigating within special relativity, during its prime of popularity at the time, L. deBroglie arrived at a similar conclusion, noting that as a consequence of phase coherence the rotating atomic electron must be 'in phase with itself' [20]. In the theoretical context of the era that came about by canceling the relativistic distortion of mass by that of frequency (p. 449 in [20])

Now, in the case of angular momentum in SI-units, $kg\ m^2/sec$, if one applies the ideas herein of rotations and counter-rotations to a particle and an incoming signal (respectively left and right terms within separate brackets below)

$$\left[\frac{kg{\downarrow_3}m^2}{sec{\downarrow_2}}\right]\ \left[sec{\uparrow_1}\right]\ , \tag{16}$$

letting a down-arrow indicate slowdown or decrease and an up-arrow speeding up or increase due to internal clocks one arrives at the following conclusion about the connected events indicated by subscripts 1,2 and 3. When the signal's time shortens (Eq. 16, its index [1]) as described in Section 2 above the particle's clock counters relativistically and goes slower [2] while its mass follows proportionally to latter [3], it has to do if it is the same particle. The more of relativistic torque the particle receives the heavier it will appear and the slower its clocks will tick. A particle having incurred such a transition may relay it to a 3:rd observer. This simple construction, building on the well-known definition of angular momentum[11], opens the prospect of being able to understand the general-relativistic effects of gravitation on mass and time in terms of physical processes.

Namely, return to the velocity of Eq. 14, which was generalized from the electron's group velocity, αc, square it and put it in a context of rotations like that of the Lorentz factor $c^2 = \mathcal{L}(c^2 - v^2)$ of [2], treating it like any other velocity,

$$\sqrt{c^2} = \mathcal{L}\sqrt{\left(c^2 - \Big(\frac{c}{\mathbf{K_2}}\ \frac{\overline{\Delta q}^2\mathbf{C^2}}{h\nu}\ \frac{a^2}{b^2}\Big)^2\right)}\ . \tag{17}$$

This factor will cause the same effect on a recipient particle as that of a relativistic velocity. Most, if not all particles have angular momentum in one way or another so the processes of 16 above will take place. (Besides, probably every object in the universe has some kind of, at least orbital, angular momentum in a chosen context). Eq. 17 is reminiscent of Eq. 33 in [15], below with the refractive index $n(r)$ moved to the right side

[10] For energy $[m^2\ kg\ sec^{-2}]$ the dimension is (=local-nonlocal-nonlocal) so multiplying by time (sec) yields [action]$=m^2$ =(local). This is also the dimensionality of angular momentum, $kg\ m^2\ sec^{-1}$, in the present theory. Both mass and time are non-local.

[11] The inherent angular momentum of a particle-object without environmental influence increases when it spins faster.

$$\frac{N(\mathbf{r},\omega)}{n(\mathbf{r})} = \sqrt{1 - \frac{m^2 {c_0}^4 \Omega^2(\mathbf{r})}{\hbar^2 \omega^2}} \tag{18}$$

where $\hbar\nu$ is a matter wave, based upon a theory claiming [21][12] that, generally, it is possible to model the effects of gravity on matter particles and matter-waves as a kind of refraction. Modeling gravitational effects as refraction is a promising approach to substituting abstract geometry for concrete physical processes:

Eq. 16 has retained elements of physical processes instead of plain mathematics but in order to see them clearly consider first the essence of the notion of relativity of movement. An emitter approaching close to the speed of light will be judged by the receiver of its signal to have velocity, say $v = .95c$. Then, Terrestrial intuition craves that the emitter of the signal should have velocity $c - v = .05c$, by reference to the signal, which is known to be wrong. Relativity theory, while clinging to its distorted Cartesian coordinates, avoids the issue by claiming that light doesn't have any rest frame. However, in the context of signal processing involving rotations substituting relativistic space-time geometry as in Section 2 above the logics is different: Here, both the emitter and the receiver of the signal will see the same torque and apparent velocity increase and decrease in the upper and lower halves of a rotating dipole - which is the signal, even whether or not the relative velocity is receding or approaching. One arrives at the conclusion that, in place of geometrical external coordinates,

The receiver of the signal measures its environment with its internal clock, (19)

for example the velocity above, a notion that is fully accessible to Terrestrial intuition and one that can easily be generalized in the fields of cell biology, medicine, psychology, politics, sociology and even science.

So, if one elaborates further on Eq. 17, putting it in a context of a local emitter, $\overline{L}$, and a non-local recipient, $\widetilde{N}$, of a signal, the recipient having some angular momentum,

$$\overline{L}\,\sqrt{c^2} = \sqrt{\left(c^2 - \left(\frac{c}{\mathbf{K_2}}\,\frac{\overline{\Delta q}^2\mathbf{C^2}}{h\nu}\,\frac{a^2}{b^2}\right)^2\right)}\;\widetilde{N} \tag{20}$$

comparing with Eq. 6 [13]

$$\sqrt{c^2}\overline{t_L} = \widetilde{t'_N}\sqrt{(c^2 - v^2)} \tag{21}$$

the stage is set for the recipient of the signal to analyze it, Eq. 21 and its environment too, Eq. 20, by using its own clock as described in Section 2, consistently with the equation above quoted from [21] the square root factor of which increases the refractive index (eqv. of a slower velocity $\rightarrow$ dilated time). One may now proceed and pursue the line of thought of the previous papers in this series about the physical nature of the line increment, which appears in a numerator of Eq. 14, in turn its squared form, its particle context, and its cosmological context.

[12] In Eq. 18 $n(r)$ is the refractive index for light in the gravitational field, $N(r)$ is the refractive index for deBroglie waves in the gravitational field, $\hbar\omega$ is the deBroglie matter wave providing a Hamiltonian, and $\Omega^2(r)$ is a positioning factor on the time component of the interval, ds^2.

[13] The emitter, in who's frame the signal propagates is local whereas the receiver of the signal is non-local in the signal's wave front and its own electron cloud as discussed for example in [10]

The line increment was derived by defining unit time intervals of observation in a mathematical construct based on the inverse four-velocity in one spatial dimension giving a geometry with a single linear momentum axis accommodating the line increment, a perpendicular velocity of equal magnitude, $\overline{\Delta q}/s = v/s$ and a radius inverse of the line increment [8] [9], a geometry reminiscent of both the atom and the universe [22]. The squared form of the line increment arises from its proportionality to the perpendicular velocity when using the latter to expand from one (v) to two (v^2) perpendicular spatial dimensions, like, for example, the surface segment of a sphere. Its interpretation as angular momentum explained above in the paragraph of p. 10-11 positions it to substitute for the time contractions and dilatations of Section 2: Momenta are additive so the particle to the right in Eq. 17 takes account of the momentum added from the environment and counters with a time dilatation and an apparent increase of mass as in 'Eq.' 16 which makes sense out of the similar form of Eqs. 20 and 21.

In the context of a particle, the squared line increment provides for mass as evidenced by the stoichiometric relations between it and the W-boson, the Z-boson and the Higgs particle [17], particles that are thought to have been involved in mass generation in the standard model of the early universe. The squared line increment appears with a fraction of the electron's mass in the Bohr atom (Eq. 9 in [1]) and this surface element is seen to be the source of the electron's rise to a higher energy level (Ch. 5 in [1]). It is also possible to relate the difference of mass between the W-boson and the Z-boson to the squared line increment based on the notion of 'resonance' (Ch. 5 in [23] and p. 7 in [17]). In such a case resonance requires an even (free of remainder) fraction of the mass difference which turned out to be 1/3, 3.6 GeV, twice the mass of the π_{1800} meson. The latter contains the quarks necessary for building a proton and/or a neutron hinting at a mechanism of creation of primordial matter (see also [17]). 3.6 GeV is also the average mass of the $c\overline{c}$ mesons[14] so it is tempting to speculate that 1) they too were involved in the creation of primordial matter and 2) the latter occurred in an environment where the mass difference between all the $c\overline{c}$ mesons was statistically insignificant. Then one is back to the sturdy barricades of contemporary physics with a new perspective on the fascinating Eqs. 10-11 and 14. It is about the well-established path integrals - are they justified by the world and the universe bathing in a high-energy environment, like the hypothetical case of the $c\overline{c}$ mesons above? The affirmative answer lies in interpreting the line increment as equivalent of the local Hubble apparent expansion rate. This 'crack in space', its equivalent energy that is, provides for such a high energy environment - leveling all known particles. Consequently, any particle derives its mass from the numerator of Eq. 14 and may do its leveled path-integral talk *via* the denominator - the light signals.

These thoughts are somewhat similar to and somewhat different from the contemporary ideas about a 'Higgs' mass field (herein H_0) and the resonance bosons providing mass in the early universe. However, standard cosmology, which is based upon special and general relativity theory, has failed to prove its abstract concepts by astrophysical observations so it remains 'speculative' as to the physicality of those (mathematical) concepts. The inverse statement is also true, that many astrophysical observation campaigns are biased by the desire to prove the theory even though it is not known if it is correct. Therefore - the universe is still up for grab and the following is a short description of the author's own ideas about the matter.

A good starting point is the universe's 'dark energy' - 'dark matter', which is so intensely written about these days. The particle calculations referred to in the paragraph above also yield a mass frac-

[14].. a result good enough for justifying spending time on writing the computer program which gave this result [24], no-one does such calculations manually.

tion which is less than 10% ($\tilde{4}$%) of the equivalent mass added [17], [23], suggesting an explanation in terms of particle stoichiometry rather than hard-to-understand general-relativistic geometry. In the much simpler local-nonlocal geometry of this series of papers [8] [9] every unit length has a line increment, which is interpreted as the local apparent Hubble expansion. This line increment has a local square (e.g. Eqs. 10 11 14 herein) to which corresponds in this geometry two perpendicular velocities in a nonlocal frame of observation. This construct provides for 'angular momentum'. By generalizing Copernicus' principle about the solar system to the universe, e.g. as in [25], that there is no privileged observer, every unit length along the line of sight must be constructed the same and have the same line increment. The latter add up, until, at the universe's relativistic horizon, their sum become equal to the velocity of light. This is the edge of the universe - its boundary if one adopts the idea that there is no higher (longitudinal - head-on) velocity than that of light in vacuum. The equivalent mass of the unit line increment at the horizon can hardly be concentrated at a point (like in Big Bang theory) so it is distributed on a sphere having radius as the universe. As seen from there, the same applies to the local universe here - it has, besides its local unit length and local, tiny, line increment, a unit element of dimension m/s which harbors light. The unit line increment inferred from the 'other side' is similarly non-local here as to its matter content. - There is reciprocity of positions leading to duality of local-nonlocal. Furthermore, since the universe is closed by any two observers at the extremes of its radius it is impossible to escape from it - Any evaporation (mirror-reflection) into the future as in Big Bang cosmology is fictitious, 'recycling' of its non-local mass is more likely.

Now it is time for the atom to enter the arena. One arrives at exactly the same conclusions if one surmises that the universe and the (primordial) atom have the same geometry. Namely, if the electron corresponds to the local universe, like the Earth in the solar system, it will, from its perspective, judge the mass of the atomic nucleus to be rotating (like the Sun) at the edge of its 'micro-universe'. It is further known that in the laboratory frame of observation, which is that of the atomic nucleus too, the electron is seen to rotate so fast that it appears non-local (the so called 'electron cloud'). Since the electron has angular momentum, which may be interpreted as (and probably is a very fast) rotation one arrives at the unavoidable conclusion that from its stationary perspective the nucleus is non-locally distributed on a spherical boundary.

Before proceeding with the atom's geometry applied to the universe note the following implications (generalizations) from the previous paragraphs. 1. The line increment grows longer when approaching a massive horizon. 2. A massive horizon attracting an increasing line increment is characterized by more rapid rotation, which is non-local (perpendicular to axial momentum). 3. A massive horizon stretches the longitudinal line increment. (....dark energy?) - In the case of black holes at the center of galaxies the rotation is visible but disappears from sight at the boundary. Many galaxies have 'halos' hypothesized to contain dark matter the gravitational effects of which just scale to their baryonic mass [26] - this is a kind of stoichiometry between local and invisible (read: non-local) mass. Voids between trabeculae of galaxy clusters stabilized by 'dark matter' may have a higher apparent Hubble rate. There are many observations that are compatible with this cosmology, but is there such a thing like non-local mass? Of course there is - matter waves known to exist for 100 years disprove the idea that all particles got their mass at the beginning of time. Instead, the mass can get into and out of a particle in real time. As shown in [1] the non-local mass can be modeled by analogy with the 'dark', kinetic, energy at the nodes of electromagnetic radiation, the kind of energy that has remained un-noticed on every physicist's desk for 150 years. This quantitative theory yields non-local flux cells of radius r_Z - analogous to galaxies, mediating local electron jumps between energy levels - analogous to jets from astrophysical objects and the local excitation at the flux cell level balances precisely all the non-local flux cells on the atom's surface to the effect that the matter must choose between being local along the line of sight or being non-local on the surface of the atomic sphere. This result is obtained from the plain Rydberg constant (right side of Eqs. 14 and 15 in Ch. 4 of ref. [1], in geometrized units) using $M_e = \hbar/2r_Z$ for the electron's mass,,

$$1 = [n^2] = 2r_Z \frac{1}{4\pi {r_B}^2} = \frac{\hbar}{M_e 4\pi {r_B}^2} \tag{22}$$

where r_B is the Bohr (ground state) radius. The interpretation of Eq. 22 is that in the atom, the density of 13 is shared by the shuttling electron's mass, M_e, and the electron cloud distributed on the spherical shell $4\pi {r_B}^2$. Hence, applying the atom's geometry to the universe allows interpreting its apparent expansion as the visible half only of a material universe that is ongoingly sustained by non-local matter in a process similar to lasing between atomic energy levels.

4 Concluding Remarks

In this and the most recent papers in this series [1] [2] [3] relativistic effects on length, time and mass are ascribed to physical rotations taking place at the recipient's wave-particle interface and not to the geometry *per se* like in mainstream and text-book physics. These fundamental processes should be distinguished from the derived characteristics of relativistic space-time: Every geometry has its own peculiar characteristics, polar coordinates have their angles etc. Cartesian geometry has its Hilbert space and relativistic space-time has its four-vectors etc. A peculiarity of relativistic space-time is that some of its most important concepts and results involve the canceling of opposing relativistic effects. This applies to all its 'invariant' measures (for example involving the dot products of its four-vectors) and to deBroglies' particle vibration-frequency yielding phase velocity which was mentioned in the previous section. The author's proposed geometry [9] is unique in that it has a non-local dimension, perpendicular to its linear momentum. This geometry is simple in that it limits the number of assumptions about the external world. As has been shown above and in [1] and [2] it applies robustly at the particle level.

Why should one carry along a load of assumptions about the external world like in various abstract geometries when one can limit oneself to the concrete physical process taking place at the particle level? Perhaps the answer is the psychology to be guided by a higher meaning of things somewhat difficult to understand by invoking a more abstract level - a kind of modern shamanism as practiced throughout history by certain tribes. For more than a hundred years certain phenomena in physics have been divided into two categories, those that are jaw-droppingly consistent with relativity theory and those that are jaw-droppingly inconsistent with it. A more nuanced approach is now possible - namely trying to find the concrete physical processes that lie behind those 'relativistic' effects, starting all over from 'Eq.' 19. The author's own ideas about these processes may not be 100% correct but, at least, the veil of space-time geometry has been removed, and one can clearly see that there are features beneath.

By reasonably pinpointing physical mechanisms at the particle - wave interface that are causing relativistic effects one is a step closer to understanding why a line increment indistinguishable from the local Hubble rate in its ΛCDM-context can be derived from the plain Bohr atom in its ground state. The reason must be that since current standard cosmology relies on relativity theory it derives its ultimate roots from the very concrete physical processes taking place in the atom.

References

[1] E, Cerwen (2025) The concrete physical mechanism of the electron's signal absorption as obtained by suppressing relativistic space-time and the energy levels. Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics Cosmology # 38. (Note: The author's own items in this reference list are mostly un-edited and contain some known errors)

[2] E. Cerwen (2025) Light and matter seen with the so simple derivation of the Lorentz Factor that explains (almost) everything. Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics Cosmology # 37.

[3] E. Cerwen (2024) Reshaping the electron ....once more. Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology # 36

[4] Terrell, J. (1959) Invisibility of the Lorentz contraction. Phys. Rev. 116, 1041-1045.

[5] Penrose, R. (1959) The apparent shape of a relativistically moving sphere. Math. Proc. Camb. Philos. Soc. 55, 137-139.

[6] D. Hornof , V. Helm, E. de Dios Rodriguez, T. Juffmann, P. Haslinger & P. Schattschneider (2025) A snapshot of relativistic motion: visualizing the Terrell-Penrose effect. Commun. Phys, May 1, https://doi.org/10.1038/s42005-025-02003-6

[7] Ota, M. et. al. (2022) Ultrafast visualization of an electric field under the Lorentz transformation. Nature Physics https://doi.org/10.1038/s41567-022-01767-w

[8] E. Cerven (2003) Space-time dimensionality of plain physical observation Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology # 2

[9] E. Cerwen (2019) Physics in one dimension with perpendicular non-locality J. Phys. 1275(1) https://iopscience.iop.org/article/10.1088/1742-6596/1275/1/012054

[10] E. Cerven (2019) Some fascinating consequences of replacing special relativity with a concrete physical mechanism using Maxwell's relativistic equations. Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology # 26

[11] R. Becker and F. Sauter (1964) Theorie der Elektrizität, Erster Band, 18:e Auflage, pp. 259-266 B. G.Teubner Verlagsgesellschaft, Stuttgart.

[12] E. Cerwen (2023) New Light on Old Light - Reinterpreting the Cosmological Redshift as a Rotation at the Observer's Matter - Signalwave Interface Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology # 33

[13] E. Cerwen (2020) What Is a Photon and Where Is Light's Momentum In an Onboard Laser? Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology # 28

[14] E. Cerwen (2016, 2024) From atom to universe in a 1+0 -dimensional world Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology # 20

[15] Erik A. Cerven (2010) Quantitative Analysis of Atom and Particle Data Yields the Cosmological Expansion Rate in the Form of a Vacuum Instability. Proceedings of www.scienceandresearchdevelopmentinstitute.com. Quantum Physics Cosmology # 13

[16] E. A. Cerwen (2019) The case of the fifth, non-local dimension - unveiled by fundamentals of light-matter interactions. Proceedings of www.scienceandresearchdevelopmentinstitute.com. Quantum Physics Cosmology # 27

[17] E. Cerwen (2024) The Remarkable Apparent Stoichiometry of Particle Creation at the Universe's Relativistic Horizon. Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology #35

[18] Wikipedia (2025): Lambda-CDM model (as of August 2025), see also https://pdg.lbl.gov/ , its 'Astrophysical Constants and Parameters' , baryon density

[19] (Cerwen) Frame Signatures of Physical Entities, Table posted at www.scienceandresearchdevelopmentinstitute.com, quantum physics & cosmology pages

[20] L. deBroglie (1924) A tentative theory of light quanta. Phil. Mag. (47) 446-458

[21] J. Evans, P. M. Alsing, S. Giorgetti, and K. K. Nandi (2001) Matter waves in a gravitational field: An index of refraction for massive particles in general relativity. Am. J. Phys. 69 (10) 1103-1110

[22] E. Cerven (2001) On the physical contexts of Lorentz transformations around zero time. Paper submitted to the VII:th International Wigner Symposium, Baltimore Ed. M. E. Noz., partly published in [9]

[23] E. Cerwen (2022) Exploring the nuclear physics of factorizing the Planck length. Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology # 31

[24] E. A. Cerven (2009) Hadron spectroscopy by reference to a periodic energy. Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology #12 There is a link in this paper to downloading the software. Runs on the early Windows (R) versions like around Win NT probably up to Win 2000 and probably also depending on software distribution and requiring not too speedy computers. See also E. A. Cerven (2006) Attempts at Systematizing the Masses of the Elementary Particles - Focus on 3.6 GeV. Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology #7

[25] E. A. Cerwen (2014) Non-locality, Copernicus' principle, the density of CMBR, and a quantitative relation between the Hubble rate, the Planck length and ground state dynamics. Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology #19

[26] S. S. McGaugh (2014) The third law of galactic rotation arXiv:1412.3767v1 [astro-ph.GA]