What Is a Photon and Where Is Light's Momentum In an Onboard Laser? *

Erik A. Cerwen*

**www.scienceandresearchdevelopmentinstitute.com*

Feb-Aug. 2, 2020

Abstract

An effort has been made to find evidence of the existence of the elusive 'photon' which has been claimed in the humanities literature to be vaguely defined in physics. Three different approaches were explored, 1) Maxwell's classical equations modified in the framework of relativity theory for the purpose of finding out exactly in which phase of the wavelet the absorption takes place, 2) The Bohr atom in order to elucidate the role of the absorbing matter, 3) Quark dynamics taking place in an electromagnetic wave, possibly a 'Compton particle' and 4) Evaluation of other theoretical approaches: 1) Maxwell's wave description was re-written in terms of the potential energy of the field at the antinodes and its kinetic energy (the rates of change of the field components) at the nodes hidden non-locally in the Stokes curl of the wave. From this classical perspective the angle $\pi/4$ relative to the node and the antinode appears to have a role mediating the wave's interaction with matter whereas its momentum could be carried by a phase shift of $\pi/2$ of its transverse electrical field when absorbed by the electron cloud. The classical analysis was carried on to Compton scattering wherein deBroglie's electron's internal frequency-matter wave was found to mediate the wave's frequency shift. 2) A factorization of Planck's constant based on the Bohr atom in the ground state provided evidence that if there is a photon momentum then it emerges at the moment of wave-matter interaction and may not necessarily be present in the wave as such. In this quantitative approach the Bohr atom emerged from the factorization partly in the form of two magnetic monopoles surrounded by currents. Hence, 3) since a) monopoles have been implicated in quark confinement and b) Compton scattering appears near an energy level where electron-positron pairs may be created, these having just one magnitude less rest-mass than the 1:st generation quarks the ability of an electromagnetic wave to sustain quark dynamics was investigated. Both the proton and the neutron as well as the pions could be found in such quark dynamics. The dynamics could be related quantitatively to the W and Z boson masses expressed in the form of axial and vector currents and a vacuum factor found in Planck's constant. The proton as well as the pions appeared at their proper phases in the oscillating electromagnetic wave and numerical values of their masses could be deduced. Furthermore, the permittivity of space could be related to theory and expressed numerically within less than a quarter of a percent as a quotient of the electron's mass over that of the proton.

Published on the Internet on Aug. 3 2020. Citation: What Is a Photon and .. Proceedings of www.scienceandresearchdevelopmentinstitute.com , Quantum Physics & Cosmology No. 28 (2020). Email: cerven@scienceandresearchdevelopmentinstitute.com

1 Introduction

What is a photon? Is it a wave packet in an electromagnetic field spanning one period of oscillation, a point-like particle substituting for Maxwell's equations, a cigar-shaped object miraculously contracted by relativistic effects, an abstract mathematical object, an electromagnetic wave, discrete in terms of energy, shuttling back and forth between various materials, or just a fancy word replacing the Bohr-Planck energy levels? It turns out that even though the word 'photon' is in general use also in scientific literature, what it really stands for is as unclear as were it just a figment of the imagination. Perhaps the last alternative has some kernel of general validity - it is another word for a packet of energy defined by two different energy levels in an atom. - A mere verbal simplification like in the modern example of 'computer program' turned into 'software' turned into 'app' , which are different words for the same process of writing and executing commands for electronic processes taking place in transistors. If the photon is defined as another word for electromagnetic field energy levels recognized by the absorbing - emitting atoms the implicit meaning is that it refers to a process taking place during the interaction between light (electromagnetic radiation) and matter. In contrast to the computer example above these concrete processes are little known beyond descriptive mathematics and merit further investigation and that is the purpose of the present paper.

It can easily be verified by reading the scientific literature of the 20:th century that the photon (first announced in ref [1]) was thought to be a point-like particle transferring mechanical momentum to the matter. For example, the intensity of electromagnetic radiation was thought to be related to the photon particle density [2] and efforts were made to reconcile its supposed being a particle with light's known wave properties *via* dispersion relations by analogy with matter waves [3] [4]. Besides, the 'photon' was known to carry the energy of the electron's Bohr quantum jumps in the atoms-molecules and to cause thermal agitation in its infrared spectrum, and later also acquired the role of exchange particle in elementary particle dynamics. In modern optics the word tends to be used for an electromagnetic wave that carries a quantum (indivisible by definition) of energy but the particle idea hangs on (cf. [5]).

It was the Compton scattering of hard radiation that prompted the photon particle concept that became such a widely used blueprint for the interpretation of various light-matter interaction phenomena in the 20:th century. This concept should have appealed to the most influential scientists in the 1920:ties who were rooted in the mechanical-thermodynamic world picture of the turn of the previous century. And it fitted well with the then newly discovered Planck's constant that seemingly dictates that the radiation is 'quantized' in energy levels, '$h\nu$'. However, looking back at the Compton quantum [6] reveals that the equivalent mass in scattered light only is a mathematical tool in the derivation of the scattering formula (Eq. 2 in ref. [6]); no concrete mechanism is presented how the momentum is created. And, how could light be both a particle and at the same time propagating waves as it was already known to be from Maxwell's equations (p. 502 in ref [6])? A rescue out of that dilemma could have been if the light waves had had a velocity dispersion such that the sought particle could be defined in the 'group velocity' like in the case of matter waves (cf. [4]). This idea was abandoned in the atmosphere of the then increasingly popular special relativity theory which requires that the velocity of light has a unique value and that the 'photon' is mass-less. The dilemma persists to this day and is shrouded in verbal expressions such as, notably, the 'wave-particle duality'.

However, it has been shown that the Planck constant can be factorized [7] [9] to yield meaningful physical interpretations of the black-body thermal distribution and the Schrödinger equation. This softens the quantization impact of always having the constant associated with radiation frequency to express the radiation's energy. Furthermore, the transition between Thompson and Compton scattering, where the radiation starts to behave as particles, occurs around a frequency which slices the unit length into line increments equal to one of the factors found in the factorization of Planck's constant [7] [9], hinting at the possibility that the particle properties may appear above a threshold because of some unknown mechanism. In parallel, a geometrical framework was developed in which the 'non-locality' of the electromagnetic field could be defined quantitatively [10], which is a concept lacking in the Faraday tensor representation of Maxwell's equations and also lacking in SR generally since the space or time coordinates of even a space-like separated observer can always be defined in SR. The co-existence of a non-local frame of observation, lacking space measurements, with a local frame of observation where the momentum is found, agrees with the notion in quantum physics that the wave does not change until an observation is made. When applying this geometrical framework comprising non-locality to Maxwell's relativistic equations evidence was found that 'photon' momentum as well as the orientation of the electric field might have its origin in a kind of light-matter interaction solely attributed to waves, which would make the particle concept unnecessary in the case of 'soft' radiation (i.e. energy below the boundary between Compton and Thompson scattering). In this new theory the interaction between the non-local field and the local matter takes place *via* a Lorentz transformation and not *via* robust particle momentum transfer: The momentum appears out of the field at the moment of field-matter interaction and does not necessarily exist prior to the momentum transfer. The physical process of non-local factors in the field turning into other, local factors is the cause of momentum transfer. This idea will be further developed and consolidated in the present paper and some interesting sequel will be found.

2 What is a 'Photon'?

A common way of illustrating the photon found in text-books is in the form of the radiation's field components extending one wavelength along the axis of lights propagation, like in Fig. 1 where the field components reach extremum values at the 'antinodes' and are zero at the intersection of the curve with the propagation axis at the 'nodes'. This picture neither conveys the dynamics of the interacting field components as time passes along the axis nor the wave front, which extends further out perpendicularly to the waves forward direction. Even though SR forbids light quanta[1] to have a rest frame such a traditional representation based on coordinates with associated quantities is a good starting point for a better understanding of its properties. In traditional treatises the focus is usually on the field components at the antinodes where atoms in standing waves tend to settle [11] and not much attention is paid to the nodes. At the nodes the rates of change of the field components with their associated curls attain maxima providing kinetic components supplementing what may be regarded as an electric (and magnetic) potential at the antinodes. Historically, the electric potentials (dipoles, polarizations) were readily understood to be interacting with charged electrons whereas anything that happened at the nodes, like the non-local Aharonov-Bohm-Eherenberg-Siday effects long remained inexplicable. As is well known, the kinetic components at the nodes are phase-shifted relative to the fields by $\pi/2$ (Fig. 2, black and red curves) and should be equally great in terms of energy at their maxima, in principle, since the radiation does not intermittently loose any energy during one period. This settles the fundamentals of the field for as long as one keeps in mind that the

[1]If there are any such quanta-particles, that is. As a counter-argument polarization filters can be taken as experimental evidence that light waves have a rest frame.

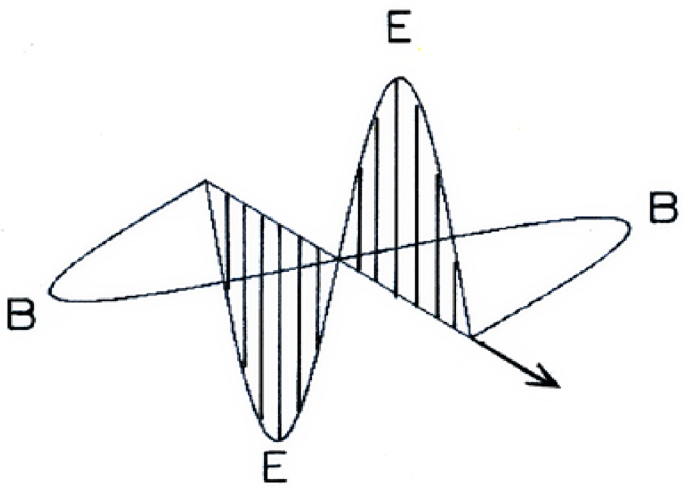

Figure 1: An often seen representation of an electromagnetic wave propagating in the direction of the arrow (x-axis representing the space or time axis), with its electric (E) and magnetic (B) fields. This kind of representation neither captures the time-dependent dynamics of one coordinate yielding the next, nor the wave front. In the context of the widely accepted special relativity theory wherein light quanta have no rest frame it also fails to explain why at all there are x-coordinates with associated values of E and B.

field moves forward while its perpendicular components appear sequentially to the signal-processing observer even though they seem to be simultaneous to the reader-observer of Fig. 1.

Then, there is the light-matter interaction. At some moment during one oscillation cycle the field catches up with the orbiting electron of the absorbing atom and transfers an amount of energy that matches the atom's geometry and its permissible electron wave functions. When does that happen? If an interaction at the field maximum is thought of as an electric potential-dipole 'pull' from a distance then a kinetic interaction at the node might be thought of as a 'push' through the electron's center of mass. The potential and kinetic components are phase-shifted by $\pi/2$ and their product, $sinx\ cosx$ has maximum values at $\pm\ \pi/4$ (Fig. 2). At these latter coordinates, the acceleration-deceleration of the field components are maximal and the combined contribution of the potential and the kinetic components, $sinx\ cosx$, to the total energy (intensity[2]) of the wave packet are also maximal. The function $sin\ x\ cos\ x$ gives maxima at x-coordinates where the field accelerates or decelerates whereas $sin\ x{+}cos\ x$ indicates decelerating fields and $cos\ x{-}sin\ x$ only accelerating ones. Choosing $sin\ x\ cos\ x$ out of the three would be relevant to the potential energy being a platform from where the kinetic energy acts or *vice versa*: An electron coupled by dipoles to the field should experience a force similar in magnitude but opposite, when the field accelerates and when it decelerates. (These ideas are different from the 'Poynting vector' construction which ascribes the radiation's intensity solely to the field maxima). Moreover, the electromotive force of the magnetic field (the acceleration-deceleration of the total magnetic flux, that is) reaches a maximum at $\pi/4$ and if the perpendicular electric field were to hide a momentum then the latter's decomposition into a forward-pointing component (photon

[2]By factorizing Planck's constant and sorting out local and non-local terms in the Planck distribution the radiation's intensity may be regarded as analogous to acceleration [9]

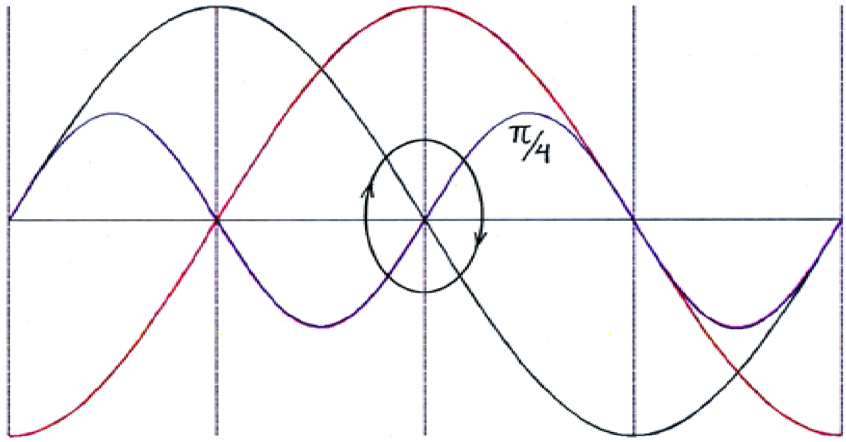

Figure 2: Illustration of the electric field component E of Fig. 1 (*sinx*, black line), the rate of change of the fields (*cosx*, red line) associated with a curl (black ellipse with arrows) and the function $sinx \times cosx$ (blue line, discussed in the text)

momentum ?[3]) would also have a maximum value here. From these manifestly classical perspectives, the coordinates $\pm\ \pi/4$ relative to the field antinodes and nodes are interesting candidates for the field-matter interactions. Before relating this conclusion to a geometrical framework comprising a local observer of momentum and a non-local observer in the field it also necessary to take into account the wavefront.

So, if one depicts the field as usual in Fig. 3A and finds the coordinate with the maximum curl at the wave node one can subsequently sketch an equivalent schematic with some new symbols as in Fig. 3 B and then go on to sketch the wavefront in two dimensions along a circular arc as in Fig. 3 C. The counter-current curls cancel most in the wave-front's forward direction yielding remaining crescents that also cancel out to form a smooth wavefront. A similar appearance of increasingly flat crescents has been obtained by examining the visual appearance of a sphere moving with increasingly relativistic speeds [12][4] The formation of a wave-front during light's emission and propagation, not only along an arc as in Fig. 3 C, but also in three dimensions, as if on an expanding sphere, is consistent with its radial intensity dependence $I \propto r^{-2}$.

In order to find out what happens when the wave interacts with an electron consider first a coordinate where the rate of change of the electric field reaches a maximum (red curve, the x-coordinate encircled by a curl in Fig. 2, which is also a right side of the E-field's down-slope where $E = 0$, black curve). This coordinate yields in Fig. 3 C a wavefront in its outermost edge composed of polarization (electric field) beneath which are the curls, the tangential counter-directed components of which cancel by Stokes theorem rendering their centers-origins non-local in the wavefront while at the same time the curls contribute to the descending polarization in the tangential direction as in Fig. 3 A. Then, let an arbitrary *non-local* observer at the center of the maximum of curls wait at a

[3]Such decomposition of field energy into longitudinal and transverse vector components is contrary to the 'all-or-none' quantum nature of absorption irrespective of light's in-falling angle so the hypothetical forward component may be thought of as merely a 'handle' for capturing the waves entire energy into the orbiting electron cloud.

[4]As for this sphere, is there *really* such a thing as a relativistic photon particle nevertheless? Not if one is to accept the non-locality of the wavefront and the invariance of the speed of light, the latter in terms of permittivity $\times$ permeability being invariant irrespective of observer's velocity relative to source.

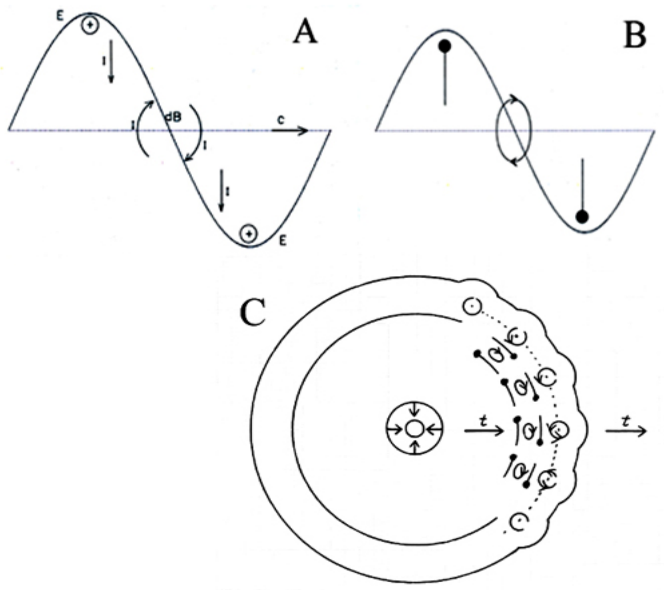

Figure 3: Schematic illustration of the electric field maximum and the maximum curl (A), the same with simplified symbols (B) and, using these symbols, the wavefront in two dimensions as a circular arc with the emitting atom in the center and the non-local observer as points in the wavefront (C). When the field changes directions (straight downward and upward arrows in A) the decreasing electric field to the left is 'eaten up' by the upward curl (ellipse) due to the magnetic field (the latter pointing upwards from the paper-figure) and the left peak vanishes whereas the magnetic field-contributed curl adds to the increasing (peak-dip in the figure) electric field on the right side of the node. The wave's curl never reaches a boundary, neither on the concave side (where it vanishes) nor on the transverse side or on the convex side (where it feeds into the next node) of the wavefront. Hence, the wave's kinetic energy hides non-locally in its Stokes' curls.

fixed x-coordinate for the wave to pass by. At the moment when a wave crest of the electric field (the antinode) passes the fixed x-coordinate the non-local observer will look into the future while a hypothetical observer associated with the wave crest will look into the past. This agrees with the herein adopted geometry [10]. The non-local observer might, in principle, be entangled in the Stokes curl for at least half an (arbitrary long) wavelength and possibly within the entire arc of the wavefront. Of course, when the signal is made visible during an interaction with matter, the non-local observer emerges from the curls at some specific Stokes boundary which turns into a 'location' and the light wave 'collapses'.

What are the optimal conditions for this, in other words [9] [10], when do the two observers communicate by way of a Lorentz transformation comprising a rotation and a boost? That interaction should take place when the non-local and the local observers meet in the wave, and, when the wavefront is optimally located for interacting with the electron cloud, which, by the 19:th century arguments above takes place at $\pi/4$ in the phase. As shown previously [9] [10] and in the Chapter 3 below the relativistic version of Maxwell's equations can be used for identifying the local observer (who is the source of the signal) and the non-local one (who is anywhere in the wavefront). The non-local observer, identified above by the cancellation of Stokes' curls is at the center of curls also in the relativistic Maxwell case, acutely well situated for measuring any kind of phase velocity, which

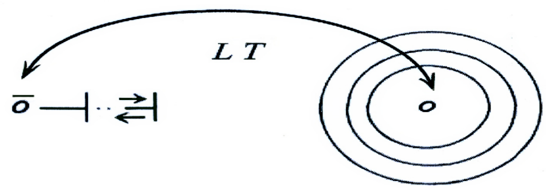

Figure 4: Schematic illustration of the local observer of momentum ($\overline{O}$, left) and the non-local one at the center of curls and phases (O, right) as defined quantitatively in refs [7] [9] [10] [8] [Appendix]

are allowed to be superluminal in SR. The phase velocity may be regarded as a loophole by which to escape from SR's constructs based on its limiting velocity of light to allow the establishment of a 'natural geometry' of the world which includes a cosmological line increment and a non-local '5:th' dimension [7] [9] [10],[Appendix]. Based on Maxwell's relativistic equations the non-local observer adjusts any velocity to the prescribed geometry such that the resulting velocity is $c = 1$ in his frame of observation; this takes place at the angle $\pi/4$ between the potential and the kinetic maxima. Rather literally, the non-local observer sees the electric field delayed because of an aberration effect like in the case of a point orbiting around the origin [13]; this allows the identification of the non-local observer's environment of curls in the Maxwell case. The local and the non-local observer, as they appear in the quantitative formulation ([7] [8], [Appendix]) are schematically illustrated in Fig. 4.

The delayed observation of the field means that the non-local x-coordinate just described, representing an instant in either the wave or the signal-processing matter -electron cloud, at the moment of seeing the electric field peak leveled (at right angles to the direction of propagation, that is) the peak will actually be ahead by $\pi/4$. The wave's actual sequence of events at time t_1 and the non-local observer's perception of these phase-shifted events are shown below and in Fig. 5 with explained notations:

t_1 : $+ \rightarrow\mid \mathbf{A} \mid\rightarrow \mathbf{I} \rightarrow \mathbf{D} \rightarrow$ event sequence in actual wave;
t_2 : $\mid + \mid\rightarrow \mathbf{A} \rightarrow \mathbf{I} \rightarrow \mathbf{D} \rightarrow$ non-local observer's perception of the wave with its field amplitude, +, appearing delayed at the moment | | of real time maximal acceleration, A. From the perspective of t_1 at A the non-local observer looks into the future of events taking place at t_2
The phases refer to oscillations perpendicular to the direction of propagation so the radiation's frequency (and less its wavelength) has an impact in the ideal case. The wavelengths absorbed and emitted into the electron orbits are typically longer than 91 nm (Lyman-series of hydrogen), which corresponds to femtoseconds (0.304×10^{-15} s) to be compared with the Bohr radii of 1, 2, 4...5, ... $\times$ $5.29 \times 10^{-11} m$ with electron orbit period of 0.152×10^{-15} s in the ground state. These numerical values, known from classical theory (e.g. [14]), suggest that the electromagnetic wave offers one opportunity per period to kick the ground state's orbiting electron into infinity without necessarily any particle at all being involved in this: Especially in the case that there are two events within a wave half-cycle that promote ionization one would observe a sharp onset of ionization at and above some frequency threshold without invoking any 'photoelectric' particle. These events may be the maximum 'acceleration' of the field seen by the non-local node (picking up the signal), and the potential

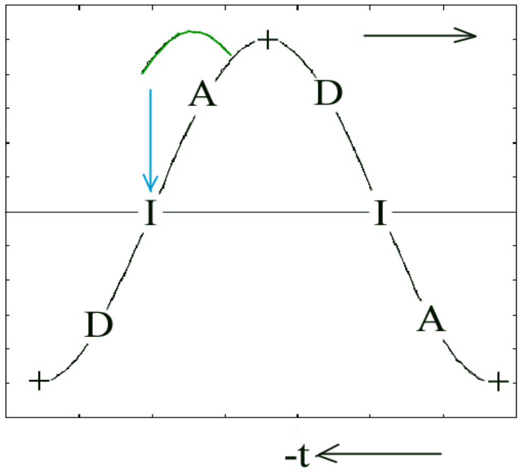

Figure 5: Schematic illustration of a signal wave propagating to the right with its maximal dipole effect at + followed by the maximal acceleration of the field at **A**, the maximal current and curls at **I** and then the maximal deceleration at **D**. Because of the phase shift-aberration discussed in the text the non-local observer at the node (**I**) sees the dipole maximum to be leveled along the blue arrow when it is actually ahead by $\pi/4$ (green). As a result of propagating this phase shift to the right, the polarization and acceleration act synergistically at a distance of $\pi/4$ from the node and the antinode when the kinetic and potential energy of the wave contribute equally. Observing the peak delayed is equivalent of time going backwards from where the non-local observer reconnects to the future, or: From the coordinate A the non-local observer represented by 'I' looks into the future and the local one, represented by '+' looks into the past.

energy at the antinode seen delayed, then followed by a deceleration of the field. The field may then be intuitively interpreted as 'picking up' the electron with all its might (potential + kinetic energy) and throwing it off to a higher energy level. The excitation threshold usually interpreted as the momentum of a particle may then be reinterpreted as the time threshold within the wave's oscillation period containing the events necessary for the absorption to occur. Alternatively, but less likely, the electron might have to revolve twice in its orbit to pick up two canceling events in the wave. Because of the quantitative correlation of half the wave period being equal to the electron's orbit period, it is reasonable to assume that emission takes place when a limiting rate within the electromagnetic wave is reached. Notably, the historical context of the quantum idea is that of Planck's indivisible constant and the Compton quantum (read: 'particle') [6], see also p. 15 etc. for a discussion of Compton wavelength *versus* deBroglie's electron-internal frequency, two different names for the same energy).

Since 1) the radiation can be constructed as continuously interacting non-local and local observers [9] [10] and 2) the non-local one is responsible for the collapse of the wave function by the Stokes curl argument above, then the wavefront may be allowed to proceed past the atom and subsequently retracted (in time and space) at the moment the electron detects its full impact. This is possible when the non-local observer connects to the future and the local one to the past [10]. Time reversals in light propagation have previously been discussed in the literature in contexts of various double-slit experiments. It is also possible that the wavefront collapses backward on its spatial radius as a result of energy equilibration in the wave, which is constituted as a whole by an everywhere connected physical process. This should be possible when there is no forward momentum in the wave *per se*, the momentum being created at the moment of light-matter interaction as discussed previously [9] and in Chapter 3. Another possibility might be that the electron senses the dipole of the incoming radiation and gradually absorbs its energy as it passes but then one would loose the gist of the non-locality of the wavefront within its curls: The Stokes curls are hidden from observation so instant effects are allowed within them whereas a wave function collapse from the dipole part of the wavefront would require some less likely superluminal velocities spanning the arc while moving the field polarization towards some location. It should be possible to design experiments to distinguish between these possibilities. In any case it is possible that at the moment when a local observer emerges from the non-local one not only is a point in space defined but also a radius reaching to the dipole remnant of the wavefront. Given that the wave's energy is contained in its transverse frequency with its forward extension along its wavelength being indifferent it is not unlikely that it adjusts to a length corresponding to the atom's radius with its nucleus picking up the signal. All of this flexibility just described arises from realizing that the wave has a non-local part, not only in theory but in the real world as shown by the various Aharonov-Bohm - Eherenberg-Siday effects linked precisely to the wave nodes but poorly understood in terms of the conventional vector potential description. These latter effects were not known at the time Maxwell's equations were formulated so there was no incitement at the time to construct a theory on the basis of non-locality.

A role of the atom's nucleus in signal absorption-emission appears likely by examining the factorized Planck's constant (cf. [9] [15])

$$\sqrt{\hbar} = \overline{\Delta q}\; 2\Big(\frac{ec}{2\alpha}\Big)\; \frac{1}{\pi Ampere} \tag{1}$$

in the context of $h\nu = \Delta E$ with, right of the arrow below, local terms rearranged to the left and non-local ones to the right:

$$\hbar\nu = \frac{\Delta E_{electron}}{2\pi} \quad \longrightarrow \quad \overline{\Delta q}^2\; \overline{Q}^2 = \frac{\pi^2 (Ampere)^2}{4\pi}\; \frac{\Delta E}{2}\; \tau \tag{2}$$

where $\overline{Q}$ is the magnetic charge and τ is the oscillation period of the wave. The orbiting electron and its energy jump upon emission-absorption, ΔE, appears in the form of a circular current in two dimensions acting on a point contracted from the surface of a sphere (divided by 4π) on the right hand side. The left side has a magnetic pole squared since circular currents are always accompanied by magnetization at their centers. Then by inference, the left side harbors the nucleus and the line increment, $\overline{\Delta q}$, so Planck's constant reveals the physical processes at play during absorption, acting as a blueprint for the structure of stable matter in the universe. The factorization suggests that the photon concept, previously linked by intuition to Planck's constant being indivisible, is actually something that has to do with the atom and its matter-field interactions. The geometry assigns the line increment squared to the local frame of observation, tentatively the nucleus, and this will be further evaluated in Chapter 4.

In summary, like before [7] [9] [10], reasonable arguments can be found that the wave-matter interaction may be due to harmonic oscillations, without relying on a point-like particle carrying momentum. In contrast to the robustly classical perspective just described the matter-less quantum particle concept with the signal's geometrical momentum equal to $p = E/c$ affords no intuitively acceptable mechanism of momentum transfer capable of guiding experimental work since 1) a particle devoid of mass can not have any momentum and 2) the energy of the light beam oscillates perpendicular to the expected direction of the momentum. Phenomena such as non-locality in the wavefront and light's momentum could have been understood 100 years ago with the help of concepts that were classical already at that time. However, in the alluring 'new physics' of the 1920's with the Compton quantum, Planck's indivisible constant and special relativity theory (SR) these phenomena appeared 'spooky' and some honest attempts to unify the photon particle idea with light waves [3] were hammered silent with the dogmas of SR. Now turning from the past to the future, equipped with a butchered Planck constant, a world geometry comprising non-locality *versus* momentum, and the just described wave dynamics preserved from the 19:th century, the question is; when does E-B-field 'software' become 'a-p-p'(hoton), if ever? Might there be some technical implications? This will be the subject of the next chapter.

3 The Dynamics and Physical Context of the Electromagnetic Wave.

The search for the photon can start in Maxwell's equations which have survived in science for 150 years. The following is a summary of previously published results. First of all a 'world geometry' which distinguishes between local events and non-local phenomena is selected as a geometrical framework ([7] [9] [10] [15] and [Appendix]). In this geometry the Planck thermal distribution, the Schrödinger equation and absorption-emission are all recast as non-local field components interacting with local terms such as 'momentum'. All physical units are characterized as being either local, non-local, or connecting the local and the non-local frames of observation, and the terms are rearranged accordingly. Doing so reveals physical processes as for example in Eq. 2 above, that would otherwise be hidden by arbitrarily scrambling the terms. In this geometry the actual physical process provides the function value of the rearranged equations. As a result, physical 'insight' emerges quasi-automatically, which is an advantage compared to just equating terms or evaluating any *measurement* like 'intensity' or 'temperature'.

One polarization component is selected from the relativistic Maxwell's equations and rearranged with its local, barred components on the left side:

$$E_y = \frac{1}{\sqrt{1-\beta^2}}\left(\overline{E_y} - \beta\overline{B_z}\right) \quad \Rightarrow \quad \frac{c}{v}\,\overline{E_y} + \overline{B_z} = E_y\,\frac{c\,\sqrt{1-\beta^2}}{v} \tag{3}$$

Here, the local term $\overline{E_y}$ is connected to the non-local ones by Lorentz transformations as in Eq. 15 in the Appendix. The barred observer represents the source of the signal, which can always be located whereas the signal-absorbing atom emerges anywhere non-locally in the wave-front as described in the previous chapter, for example in an interference pattern. A third observer riding on the light beam being able to see both cause and effect would determine that the past is known while the future is uncertain - the local observer connects to the past and the non-local one to the future as can be shown quantitatively [10][5]. Subsequently, the non-local observer is solved from Eq. 3 in terms of the local one whereby the 3:rd bracketed term below always is canceled by the prescribed geometry (the 2nd term, that is, see Appendix, eqs. 15 and 16),

[5]In thermodynamics the 'arrow of time' is related to entropy and increased disorder as time passes whereas in the present case an observation within the prescribed geometry advances time by one unit towards more certainty with non-local factors turning local as uniquely determined by the local observer.

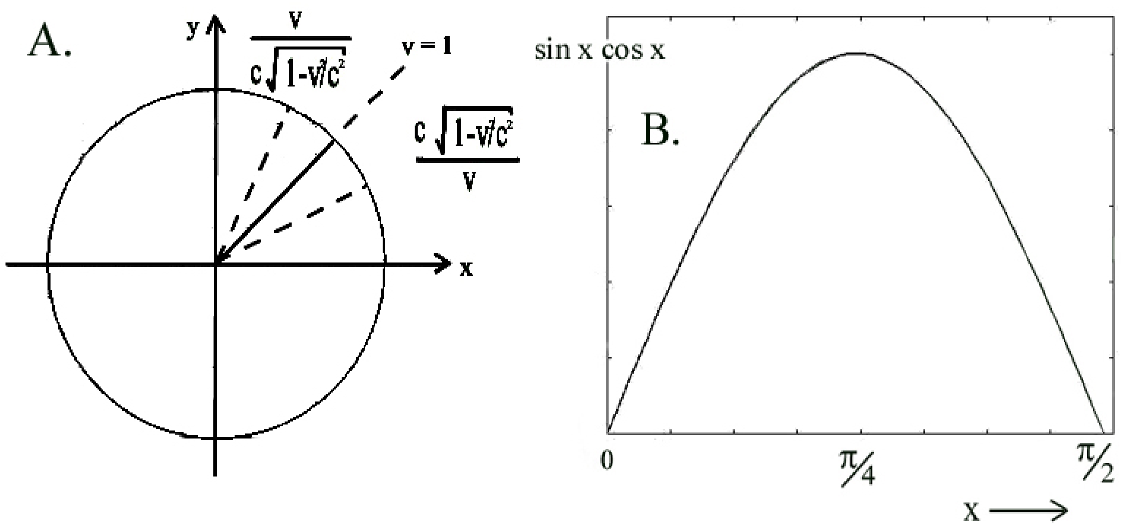

Figure 6: The phase contributions to the total energy of an electromagnetic wave as described by Eq. 4. In A, the angle between the maximum contribution from the antinode's dipole field (E) along the y-axis and the kinetic non-local component at the node along the x-axis is shown. Any velocity distortion perceived by the non-local observer, $v/\sqrt{1-v^2}$ is compensated for by the field, $\sqrt{1-v^2}/v$, (or inherently by the geometry) to yield the velocity $c = 1$ in his frame of observation, which corresponds to $v = 1/\sqrt{2}$ for $tan\phi = 1$ at $cos\phi = sin\phi$ in the local frame, prior to the observation. In B, the product of the potential and kinetic components of the energy is drawn. The maximum appears at the angle $\pi/4$ where $\bar{c} = 1/\sqrt{2}$ and $c = 1$, an angle in the focus of interest in several respects (see also text and Ch.2 and Ch.4).

$$\overline{E_y} = \frac{c\sqrt{1-v^2/c^2}}{v} \underbrace{\Big[\frac{v}{c\sqrt{1-v^2/c^2}}\ \overline{E_y}\Big] - \frac{v}{c}\ \overline{B_z}}_{non-local\ observer,\ E} + \frac{v}{c}\ \overline{B_z}\ , \tag{4}$$

and some physical process encoded by the terms is sought (the Lorentz force-contributions from the magnetic field cancel). This is facilitated by $c\sqrt{1-v^2/c^2}/v$ representing the tangent of the angle that an observer at the origin sees an orbiting point delayed as a function of orbiting velocity, like in stellar aberration [13]. Hence, the non-local observer from Eq. 3 emerges at the wave node in the center of electromagnetic curls and phases just like in the case of the Strokes' curls discussed in Chapter 2 (cf. Fig. 4). This is the reason why the signal strikes randomly anywhere in its wavefront although a light source always can be located - a perspective lacking from SR where the the whole world has coordinates, even events that have not yet been quantum-mechanically observed ![6]

The phase contributions to the wave at various relativistic velocities as guided by Eq. 4 are shown in Fig. 6 A, where the y-axis represents the potential energy contained in the antinode and the x-axis represents the non-local kinetic component hidden at the node and $sinx/cosx$ is the tangent of the angle between these components of the wave. Let the orbiting point represent the electric field seen by an observer at the origin. At the angle $\pi/4$ the kinetic and potential contributions are equal

[6]....and even space-like separated regions that can not be seen at all, also have coordinates !! , for an alternative approach that avoids over-defining space-time, see [16].

($sin\ x = cos\ x$), this corresponds to a velocity of $1/\sqrt{2}$ in the local observer's frame and a velocity of $c = 1$ in the non-local observer's frame because of time dilatation (Appendix). Consequently, 1) any relativistic or other velocity is canceled by the geometry around $\pi/4$ where $c = 1$ and 2) it is the non-local observer who absorbs the signal and measures the velocity of light to be $c = 1$. During the measurement, the composite, inverse terms in Eq. 4 cancel, the non-local observer turns local and measures at $c = 1$ in the local frame of observation a phase shift of $\pi/2$ for the electric field relative to its transverse dipole component in the wave[7]. This latter phase shift relates to the electron cloud absorbing the transverse component of the electric field turning it into a wider orbit and provides a likely vehicle for longitudinal momentum transfer [9]. Since the space and time coordinates in Eq. 15 are interchangeable by Lorentz transformations (Appendix) it is these transformations that effectuate the transitions between the non-local field and the local momentum frame.

The construction just described identifies the source and the sink of the signal, a long lamented deficiency in Maxwell's equations. Furthermore, the relativistic distortions seen by the non-local observer (the 3:rd, composite term in eq. 4) are ascribed to the matter-light interface (the 2:nd, composite term balancing the 3:rd one) at the signal-receiving end since it is the local observer, $\overline{E}$, who emits the signal and the non-local one E, who performs the calculations of the inverse composite terms in Eq. 4. This is different from SR which claims observer equivalence as if the emitter by reference to its hypothetical, 'natural', geometry could see into the future what the relative velocity of receiver will be. However, once the signal has been emitted the two observers are not equivalent any more; then there is irreversibly one emitter and one absorbing end with different physical processes taking place and the chosen geometry should serve as an instrument for identifying these physical processes. In other words, the receiver and the emitter are both working on the same signal but they are not doing the same job. The emitter makes sure there is a signal and the receiver takes care of it. The present hypothesis that a dipole field (polarization) acting from a distance may have an inherent aberration effect to an observer at the origin like in Eqs. 3 and 4 is intuitively acceptable. From Eq. 4, Fig. 6A and the arguments in Chapter 1 one must identify this observer as the non-local one at a phase shift of $\pi/4$ behind the wave crest where the 'acceleration' of the field is maximal and the kinetic $\times$ potential energy contributions from the wave yield a maximum (cf. Fig. 6B). As a consequence, relativistic velocity distortions of the wave may be interpreted to be caused by the phase mismatch between field maximum and non-local observer. As illustrated in Fig. 6A these phase mismatches are always corrected at the field-matter interface to yield the velocity of light being $c = 1$ in the non-local frame of observation. The limiting value of the velocity of light may then be ascribed to permittivity times permeability of vacuum being invariant and independent of to- and fro-velocities of source relative to sink. These conclusions rather straightforwardly arise from the present geometry but vaguer arguments in support can be found also in SR and GR: Relativistic effects in SR are prominent along the axis of movement and less noticeable perpendicular to it so rates of change of the fields and the fields themselves would undergo different kinds of distortions (leading to phase problems that must be corrected at the receiver's matter-field interface). In GR, acceleration is a fundamental property of the observer [17] whereas velocities are always relative, compatible with the idea herein that the acceleration at $\pi/4$ gives identity (read: locality - Stokes boundary) to the non-local observer who prior to the light-matter interaction was floating around in the indeterminate arbitrary relative velocity. The non-local observer picking up the acceleration and turning local is similar to 'gauge fixing'. The idea of any light beam having a dual reference beam

[7]Within the propagating wave; $v = 0 \rightarrow tan\phi = \infty, cos\phi = 0, sin\phi = 1$, the observer however measures $v = 1 \rightarrow tan\phi = 0, cos\phi = 1, sin\phi = 0$; the 'observing' electron cloud catches the wave along the x-axis and the wave shifts by the angle $\pi/2$ from the transverse orientation when it settles in the electron cloud

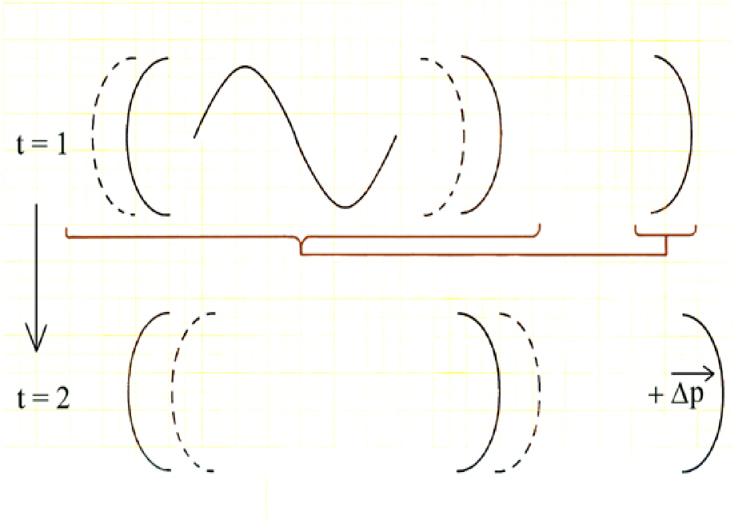

Figure 7: A 'thought experiment' where two atoms elastically reflect radiation back and forth between sender and emitter (left 3/4 of the drawing, a 'laser') and some radiation leaks to a momentum absorber at the far right. All three absorbers are connected mechanically (brown). The dashed and solid parenthesis-looking lines represent the elastically bouncing electron shells of two atoms absorbing and emitting in phase to produce a standing wave. At $t = 1$ the standing wave shifts to the right without emitting momentum to the far right. At $t = 2$ there is momentum transfer through the mirror to the far right while the standing wave shifts to the left as it would have done even without the momentum transfer indicated. Hence, there is no counter-force at the left.

(herein; local and non-local observer) has previously been explored in the context of dispersion [3]. The present theory of duality however, arises from identifying local and non-local terms by reference to the abstract geometry as detailed in refs. [9] and [10] (see also Abstract).

As for the momentum of light, a slightest asymmetry when the electron cloud contracts or expands along the axis of light's propagation leads to a charge dipole relative to the atomic nucleus at right angles ($\pi/2$) to the wave's electric field and the electron must momentarily move the heavy nucleus parallel to the dipole in order to restore electro-neutrality. This is equivalent of mechanical momentum. Such effects have recently become accessible experimentally and it has been shown that the absorption event precedes the mass movements [18]. On the one hand this mechanism makes the pushing photon particle superfluous for momentum transfer and on the other it establishes that the electromagnetic wave *per se* does not necessarily carry any momentum. This insight has some profound implications for various technical applications unimaginable in the obscuring atmosphere of photon quanta. In SR, photon momentum $p = E/c$ is a mathematical construct (just like the Faraday tensor) providing no clue to how the momentum is transferred or to the dynamics of the wave. The same applies rather often to the widely used description of emission-absorption in terms of energy levels. The herein explored classical wave properties of the radiation at the moment it interacts with matter providing a solution to an even unthinkable problem in the quantum world, may add some spice to these well-established mathematical approaches:

Consider first the case that the atom emits and the electron cloud contracts in a perfectly symmetrical fashion. Then every point on the circumference of the atom gives rise to a tangential oscillating electric field like in Fig. 3 C and the ensuing wave-front spreads spherically (circularly in the drawing). In this 'symmetrical' case the emitting atom does not give away any mechanical momentum but the field within its entire circular wavefront nevertheless has the potential to impart local momentum as discussed above. This situation touches the force-counterforce dogma of the 17:th century since all forces are canceled at the emitting end whereas an absorbing atom might still acquire momentum. The principle is illustrated more clearly in Fig 7 where two atoms -constituents of two thin-sheet mirrors emit and absorb radiation elastically and one mirror (the right one of these) is slightly translucent. A little further away on the translucent side there is a third atom which absorbs the momentum-carrying radiation, the three atoms are connected mechanically, and the momentum beat is synchronized in terms of phase and absolute length between the atoms. Then it would be possible to find conditions when the population inversion of the middle to left atoms is brought about by radiation not being aligned with the standing wave between them while the right atom nevertheless keeps absorbing momentum. Such a thought experiment is feasible if one abandons the light particle concept in favor of the phase-shift mechanism of momentum transfer discussed above. Namely, maintaining the 'light particle' concept obscures the possibility of elastic reflection at the mirrors in favor of a swarm of momentum-carrying particles substituting for Maxwell's wave description. Furthermore, by abandoning the idea of quantized photon particle energy-momentum within the beam one is free to extract any arbitrary amount of energy from the field gradients (as is factually already done in sub-cycle absorption experiments) at beyond the standing wave in Fig. 7 such as to move nanoscale capacitance-carrying circuitry mechanically connected to the laser in any longitudinal direction along the beam, also towards the beam source. The latter is because of the possible lack of forward momentum in the beam *per se* (The momentum only arises upon the absorption of light by matter, forward momentum is well established experimentally whereas backward momentum transfer might require very long wavelength lasers in order to match the appropriate molecular or atomic vibrations). Also rigorous mathematics based on Lorentz transformations in the framework of group theory open the possibility of momentum transfer in either direction [19]. Realizable or not, relaxing the energy quantum dogma of radiation a little bit in favor of maintaining its wave properties opens the lid to new thinking about the mechanisms and applications of light-matter interaction - and the quantum dogma might already have been crushed by sub-cycle absorption experiments anyway, and more recently by the turbulent behavior of light waves [20].

Then there are the problems of the role of the atom's nucleus in emission-absorption and the *reason* for the appearance of the 'Compton particle' above a certain wave frequency. This will add even more spice to the picture: Plain symmetry arguments suggest that if the non-local electron cloud interacts with the wave's local electric field then the local atomic nucleus should interact with the non-local curls of the wave that generate magnetic fields, and capture the signal. Hence, the nucleus elbows its way into the arena of signal absorption-emission dominated so far by actors of the electron's energy levels. A role for the nucleus appears naturally in the present geometry of local interacting with non-local which leads to magnetic poles surrounded by circular currents like in Eq. 2, the thermal Planck distribution, lasing, and the Schrödinger eqution [7][9] [10]. Besides the magnetic poles of these equations, the line increment of the theory, $\overline{\Delta q}$, which can be determined quantitatively, provides a possible key to the atomic nucleus' role in signal processing, as will be explored in Chapter 4.

In order to find the Compton particle (and the atomic nucleus) it is possible to start with one of the numerous contexts, cf. [21], of the fine structure constant, $4\pi\epsilon_0\hbar c\alpha = e^2$ where the unit-converting permittivity of space, $\epsilon_0 = 8.85419 \times 10^{-12}\ F/m$ is geometrized, $\epsilon_{(0,G)} = 1.072 \times 10^{33}\ C^2/m^2$ and attenuated to the level of elementary charge, $\epsilon_{(0,G,e)} = 2.752 \times 10^{-5}\ e^2/m^2$. Subsequently, the previously described (Eq. 1) factorization of the geometrized reduced Planck's constant is implemented with Ampère = Coulomb/s $=C/s$ (GU),

$$4\pi\epsilon_0\hbar c\alpha = e^2 \longrightarrow 4\pi\ \epsilon_{(0,G)}\frac{\Delta^2 e^2[c^2]}{\pi^2\frac{C^2}{s^2}\alpha^2}\ c\ \alpha = e^2 \longrightarrow 4\pi\ \epsilon_{(0,G,e)}\frac{\Delta^2 e^2[c^2]}{\pi^2\frac{e^2}{s^2}\alpha^2}\ c\ \alpha = e^2 \tag{5}$$

where $\Delta = \overline{\Delta q}$ is the line increment, the brackets, [ ] remind of the invariant numerical value of the magnetic charge by reference to e and $I_e = e/s$ is the elementary current, electrons per geometrized second substituting for Ampère. The above equation can be simplified to

$$4 \times 2.752 \times 10^{-5}\ \Delta^2\pi[c^2]c = (\sqrt{\alpha})^2\frac{e^2\pi^2}{s^2} \tag{6}$$

where the proportionality factors may be taken as the arbitrariness of the numerical value of elementary charge relative to the meter (see also Chapter 4). The above equation tells that the surface area of the line increment is equal to an elementary current on the two surface dimensions of a sphere. Since the electric charge is perpendicular to the radius by geometry ([9] and Appendix), and is known to move tangentially to the atom's radius, the right side represents the non-local observer whereas the line increment carrying momentum, Δ, represents the local observer (left side above, a comprehensive assignment of most physical units to the local and non-local frames has been done previously, cf. [9] and references therein). Both sides of the equation describe the geometry of a spherical particle that resembles the atom. The left side of the equation suggests the presence of a hitherto unknown particle associated with the nucleus that is held up by the orbiting charge on the right side.

Since the electron's internal frequency, m_ec^2/h (cf. [3] [22]) can be tied to the geometry by use of the Bohr radius, $a_0 = 4\pi\epsilon_0\hbar^2/m_ee^2$, substituting e^2 from its context with the fine structure constant, $e^2 = 4\pi\epsilon_0\hbar c\alpha$;

$$\frac{m_ec^2}{h} = \frac{m_ec^2}{\hbar 2\pi} \quad\rightarrow\quad \frac{2\pi c m_e}{h} = \frac{1}{\alpha a_0}, \tag{7}$$

and $\hbar$ can be factorized as before this hypothetical particle vibrates, alternatively the internal frequency appears as an oscillation period on the right side of eq. 6. To the right of the arrow in Eq. 7 the electron's internal frequency on its orbit is the inverse of the atom's radius, corrected by the coupling factor α. Applying the present geometry on a larger scale yields the oscillating cosmological line increment (interpreted to be a literal expansion of space in standard cosmology) as the inverse of the radius of the universe [7] [9] [15], which is analogous to Eq. 7.

Once the cosmological line increment has been found it is easy to take the giant step to the entire universe by using $R_u = 1/\Delta$ so from Eq. 6,

$$\pi[c^2]c \propto {R_u}^2(\sqrt{\alpha})^2\frac{e^2\pi^2}{s^2} \tag{8}$$

where R_u is the inverse of the line increment; the universe's relativistic horizon in the present theory[8]. In this context, the elementary currents are a candidate for generating radiation (like the CMBR;

[8]The numerical value of the line increment obtained from the Bohr atom in the ground state, cf. [15] [7] [9] agrees extremely well with astronomical measurements of Hubble's constant in the local universe using a variety of methods [23] [24] [25] [26]. Postulating that the space-time of the universe is equivalent throughout its extension at present time in the current epoch enables adding line increments until one reaches its relativistic horizon. This yields its age, 13.7 billion years based solely on the Bohr atom.

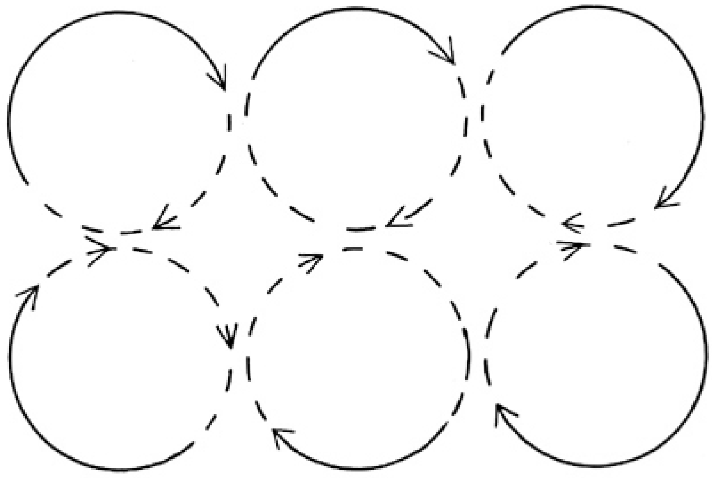

Figure 8: Illustration of the Stokes curl of electric charge on the surface of the Bohr atom deduced from Eq. 6 and Eq. 8 as discussed in the text. On a closed spherical surface the curl is everywhere canceled, making the unperturbed electron cloud non-local.

for example, bent, accelerated currents, right side, are capable of generating synchrotron radiation). The cosmology is parenthetically discussed in the footnote.[9] In Eq. 8 the elementary currents of the entire universe (right side) amplified per unit length by R_u are supported by the physical context of the number π, an interesting starting-point for re-evaluating the origin of the CMBR. In the original work on the electron's internal frequency it was shown that the phase of this vibration will persist forever (p. 449 in [3], text in italics), similarly in the present theory, throughout the universe.

The perpendicular currents, e/s, in Eqs. 6 and 8 can be visualized as in Fig. 8. Then, 1) the non-locality of the electron cloud (its charge, that is) can be understood intuitively as a kind of Stokes' curl, the currents cancel everywhere in the non-perturbed equilibrium state and 2) when uniformly distributed on a sphere like the atom, such currents would form a magnetic pole, explaining the appearance of the pole in the factorization of the Planck length[10]. Furthermore, like in Fig. 8, 3) the electron's magnetic moment can be ascribed to its charge circulating at velocity c a distance of $R_Q = r_e/\alpha$ from its center of mass where r_e is the classical electron radius (cf. [21]) so Fig 9 is also relevant to the so called 'Cooper pairs' of electrons. In higher orbits than the ground state the

[9]Dragging in the entire universe into these equations is not merely a matter of replacing the inexplicable numerical value of Planck's constant with something more robust and testable. At least three lines of evidence suggest that this may have some physical significance: First of all, the numerical value is very close to the actually observed apparent cosmological expansion rate and the units obtained from the geometry (Appendix I) agree with those of the Hubble factor. Secondly, the line increment of Eq. 1 applies to *one* Bohr atom per geometrized units to be related to *one* electron having mass 6.764×10^{-58} m, which is just about twice the energy density per geometrized units of the cosmic microwave background radiation, CMBR, 2.7×10^{-7} $MeV/cm^{-3} = 3.57 \times 10^{-58}$ m^{-2}, hinting at some simple stoichiometric process. The CMBR is thought to be generated from the last visible cosmological horizon in Standard Cosmology. Third, the geometry indicates that the local observer is on the circumference of a sphere (Appendix). These lines of evidence all converge towards a concrete role for the cosmological horizon in generating the empirically observed line increment. From eq. 8 the universe is just an instance of the number π, which closes a line around a local point.

[10]The factorization of Planck's constant yields *two* monopoles, these would be of opposite polarity in order to make a stable configuration.

electron is known to behave more like a (local) point particle.

In the original derivation of Compton scattering (Eq. 2 in ref [6]) the equivalent mass of the wave packet was used as a mathematical tool without any proof that there actually is a physical particle involved in this. A particle is expected to have some spatial geometrical extension (symmetry operations as a proxy for that will be discussed in the next chapter) and there does not seem to be any concrete proof that this is the case for light (reviewed in [27]). Instead of looking for a 'light-particle' -quantum one could instead without bias look for any physical mechanism transferring momentum from light to matter. The $\pi/2$ phase shift discussed in connection with Fig. 6 provides one such mechanism, however without specifying some arbitrary direction of hard recoil radiation. To get further one would like to use eq. 4 and its interpretation discussed in the text above on page 11 as a blueprint and transform one of the Compton scattering equations (p. 483, l. 10 in [6]), left of the arrow below,

$$(\lambda' - \lambda) = \frac{h}{m_e c}(1 - cos\theta) \longrightarrow \tau' - \tau = \frac{h}{m_e c^2}(1 - cos\theta) \tag{9}$$

where τ is the electromagnetic wave's oscillation period before and after' scattering) by use of Eq. 7, into

$$a_o \alpha (1 - cos\theta) = \frac{\tau' - \tau}{2\pi}\ c \tag{10}$$

with local terms on the left side and non-local ones to the right. Eq. 10 reveals elements of the Bohr atom, the electron's most stable environment in the universe, even though Compton scattering is not done on hydrogen atoms at all. One might therefore infer that the Bohr atom is imprinted in some way in the electron's internal structure (or *vice versa*) and interpret from Eq. 10 that scattering takes place on matter's ground state. In practice most experimental set-ups likely relied on valence electrons anyway, which have orbits similar to that in the Bohr atom ground state. This idea is not necessarily contrary to the established way of regarding the electron in Compton scattering at rest since in a 'relativistic' sense, it may be regarded to be at rest when instantaneously orbiting perpendicularly to the hard radiation's direction of propagation. Eq. 10 also has an element of the electron's matter wavelength, $2\pi a_0$ equal to a completed orbit in the ground state, as well as the electron's internal frequency, $a_0\alpha$ (cf Eq. 7). As written, the projection of the orbiting electron's (or its charge's) distance from its original location onto the x-axis is equal to some event occurring during one period of the radiation's oscillation also projected on the x-axis. Multiplying by 2π moves these events to the orbit.

Also the magnitude of the relevant numerical values suggest that the orbit periods play roles in Compton scattering. Namely, recall first the elementary Bohr orbit at 0.152×10^{-15} *sec* and quantum level absorption starting at 91 *nm*; $\tau = 0.304 \times 10^{-15}$ *sec*. The time period of the electron's internal frequency is $h/(m_e c^2) = 8.093 \times 10^{-21}$ *sec* and its deBroglie wavelength in the ground state, equal to $2\pi a_0$ is $h/m\alpha c\sqrt{1-\alpha^2} \approx h/m\alpha = 3.325 \times 10^{-10}\ m$. Then turn to the line increment in the present theory, $\overline{\Delta q} = 7.714 \times 10^{-28}\ m$. Formally, its units is $m/(ms)$, however its length takes light 2.323×10^{-18} *sec* to travel. The inverse of this time, $\nu = 4.32 \times 10^{17}\ Hz$ is a reasonable frequency around where to expect to find the transition between Thompson and Compton scattering. Finally consider the deBroglie wavelength seen from the perspective of the speed of light instead of from that of a stationary observer of the ground state; $\lambda\tau^{-1} = c$ yields 1.11×10^{-18} *sec* for the cycle period of such a wave, very close to half of the above indicated cycle period linked to the line increment. The latter, twice as much, substitutes for the electromagnetic wave at 91 *nm*; 0.304×10^{-15} *sec* whereas the former substitutes for the orbiting electron at 0.152×10^{-15} *sec*. Therefore one can reiterate all the arguments pertaining to absorption into energy levels given in Chapter 2 for hard radiation as well and conclude that in both cases the radiation's electrical field kicks out the electron without necessarily any particle-quantum involved in this. However, the rather more important conclusion that the transition between Thompson and Compton scattering takes place when *the field no longer sees the electron as a particle but as a wave* necessitates scrutinizing the final step in the numerics above: 1. The deBroglie wavelength confined to the ground state is an orbit so it represents more a non-local physical process (capable of resonating with the electromagnetic wave) than what it represents a bench-top length. The velocity in the ground state orbit is not arbitrary as for an observer in a physics laboratory but fixed by reference to the atom's rest frame and from its rest frame the velocity of light will always be the same. 2. There is no matter-wave interface in the case of two interacting waves, so the emergence of an apparent quantum-particle is somewhat paradoxical, a necessity may be, in order to get something local and observable out of everything non-local. 3. The finding that the transition between Thompson and Compton scattering takes place at a frequency relevant to the apparent cosmological expansion rate in the current (least distorted by observations into the history of the universe) epoch can be explored quantitatively in terms of non-locality as outlined in Chapter 4 yielding some corroborative results. Anyway, retrieving the Bohr atom in Compton scattering makes sense in the present theory whereas in the 1920s it would have been a nuisance obstructing from confirming the then probably much heralded theoretical prediction of a light quantum (read: particle) exhibiting mechanical momentum transfer.

Writing Compton scattering as in Eq. 10 is consistent with the procedure herein [7] [9] [10] [28] to gather local terms to the left and non-local ones to the right in order to facilitate a read-out of the physical process taking place, but is there anything physical that goes parallel to the Bohr radius? Besides the atomic nucleus and its unexplored roles in absorption-emission the electron's magnetic moment and its causal circulating charge may provide an answer. These components, momentarily defined when the electron turns local during absorption may be directed arbitrarily as shown in Fig. 9. The electron's circulating charge then turns optimal for interacting with the electromagnetic wave as shown in the drawing and the entities involved in the absorption scramble into their appropriate places. This explains why the Compton wavelength is independent of the scattering wave's frequency and always equal to deBroglie's electron's internal frequency. Namely, it is the electron and its circulating charge that does the job of exchanging the incoming and outgoing frequencies in the Compton scattering by way of its internal dynamics correcting by the factor $(1 - cos\theta)$ for the corresponding difference of orbital period of the electric field.

Another interesting theoretical result in the original Compton paper [6] is that the speed of the scattered electrons increases more when the scattering angle relative to the incident hard radiation increases. This would agree with the ideas in the present paper that the electron is accelerated out of its orbit, pushed and pulled by the transverse field maintaining its wave properties until the very moment of absorption. In the original paper [6] the transition from Thompson to Compton scattering is also discussed in terms of the radiation's intensity. In more recent investigations it has been shown that there are qualitative differences of Compton scattering depending on polarization [29] which indicates that the hard radiation too is a wave and not a point-like particle when it hits the electron. Furthermore, hard gamma radiation can be frequency-modulated by to and fro velocities and mechanical vibrations [30] which is easier to understand intuitively based on the wave picture compared to the particle picture of radiation.

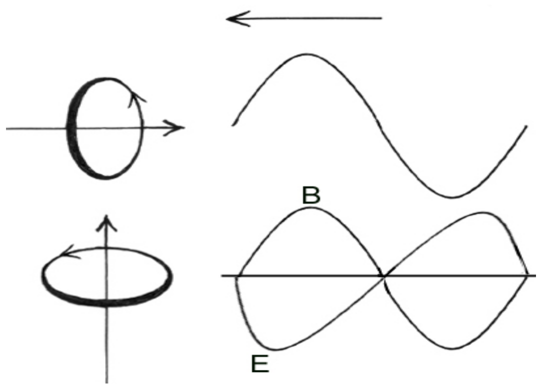

Figure 9: Two possible orientations of the electron's magnetic momentum (left) in relation to an electromagnetic wave (right) at the moment of absorption. In the upper part of the drawing only the electron's circulating charge is aligned with the electric field, in the lower part the magnetic fields are also parallel. The magnetic moment or the electron's circulating charge are candidates for providing physical content to the Bohr radius.

In the context of the present geometry, the first thing one notices in Eq. 9 to the left is that the two actors 'EM wave' (left) and 'electron' (right) have time-reversed event sequences (the terms in parentheses) so if one chooses one actor for the past then the other one is set for the future. This should fit somehow with the present geometry where the local observer is connected to the past and the non-local one to the future [10]. When turning to the oscillation period of the radiation, τ, it is assigned to the non-local frame by definition ([7], Appendix I, Fig. 4), since time is perpendicular to the momentum frame.

As for the contents of the transverse oscillations of the field there is an ambiguity about representing the intensity of the radiation. In text-books the intensity is represented by the amplitude of the oscillations like in Fig. 10 A. However, that is not necessarily the way a point observer on the x-axis of Fig. 10 A sees the oscillating field of the wave. If one sticks to regarding the oscillation as interchanging contributions of potential and kinetic energy then it is obvious that the latter, the current with its associated curls that is, will be represented by displacements along the y-axis in the drawing. The intenser the radiation the steeper will be these curve segments. The point observer on the x-axis, in expectation of a once and for all set quantum-amount of potential energy to absorb, will judge the apparent distance to this potential energy as a function of intensity and it will seem to be closer the more intense the radiation. Since, on the other hand, the increasingly intense kinetic component makes a steeper curve the oscillations seen by the point observer will by necessity turn more square-rectangular as the intensity increases. Therefore, the wave will appear to the quantum observer as a function of intensity more like in Fig. 10 B. This has the following consequences: 1) The non-local contributions of the wave will be of shorter duration so the light beam will turn more local-'pointed' (as it is in 'laser' light). 2) The $\pi/4$-component of the wave discussed above as a possible generator of forward momentum will turn into a more acute shape, so its vector decomposition into forward momentum should be more efficient (like in high-intensity lasers),.... without any 'light-particle' necessarily being involved at all. 3) There will be no precisely $\pi/4$ -phase shifted component of field acceleration feeding into the dipole phase of the electric field, leading to increased thermal dissipation. Furthermore, 4) in Fig. 10 B there is 'slicing of space' along the amplitude as well as along the axis of propagation effectuated by the frequency. The question then arises why the

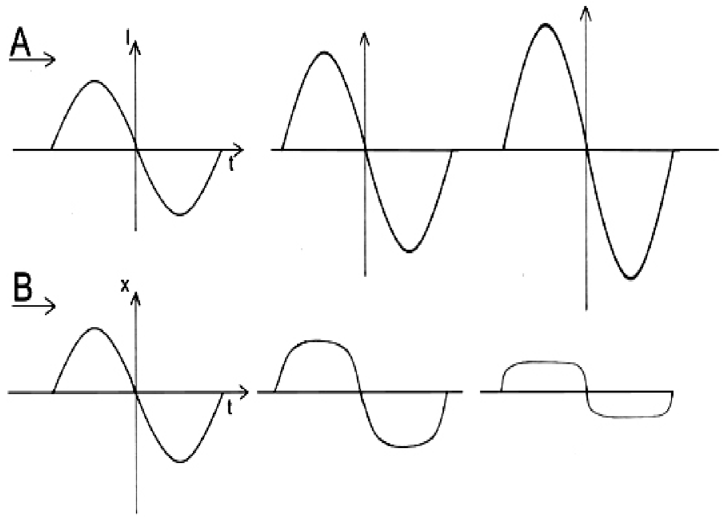

Figure 10: A: A classical representation of the intensity of electromagnetic radiation by increasing the amplitude of the sinusoidal wave, t (time) on the x-axis and I (intensity) on the y-axis. B: A representation of how a quantum observer restricted by its available energy level might see the same intensity increase as in A, in the form of the shortened apparent spatial distance, x, to the potential energy available in the wave.

radiation appears particulate at and above the Thompson-Compton scattering transition delivered by the factorized Planck constant and why this is equal to the apparent cosmological expansion rate in the current epoch - present time.

The decomposition of Planck's constant yields two pieces of these line increments and space now sliced by the frequency $\nu = \overline{\Delta q}$ yields a third piece harboring the radiation's electric potential so there are three dimensions instead of previously one momentum + two non-local field-dimensions, and three spatial dimensions are required for the extension of a 'particle'. The core volume of such a 'Compton particle', if spherical with radius Δ, would be $4\pi\overline{\Delta q}^3/3 = 6.12 \times 10^{-79}$ m^3, and if a cube moving with the radiation, 4.59×10^{-79} m^3. This imagined particle, clad in the fractional dipole charge and the magnetic moments of the radiation might behave towards the electron as if it were a material object. For comparison the electron's volume based on its classical radius is 2.98×10^{-44} m^3 and its cross section is 0.665×10^{-28} m^2. The transition between Thompson and Compton scattering is a reasonable energy level where to start looking for significant involvement of vacuum fluctuations since beyond this level positron-electron pair production soon emerges [31] [32]. These masses are only about a magnitude smaller than the 1:st generation quark masses. The possibility of the factors $\Delta^2\pi$ having something to do with matter by way of quark recruitment from the vacuum will be further investigated in Chapter 4.

However, according to Eq. 10 it is not mandatory to abandon the electromagnetic wave - matter-wave phase-matching interpretation of field-matter interaction even at the Compton energy level. The same conclusion arises from dissecting the photon by using group theory [19]: Here, the appearance of momentum by way of a forward rotation of the electric field at the moment of interaction with matter as discussed in connection with Fig. 6 corresponds to a boost to and from a mass-less photon state at infinity whereas rotations and boosts along the transverse directions correspond to moving the phase as discussed in connection with Fig. 3, hence a gauge transformation. Helicity in the direction parallel or antiparallel to momentum might arise in the sense that the electric field is partly contributed by magnetic curls. Ref. [19] might be as close as one can get to conceptualizing a mass-less particle and from the phase-moving point of view the particle still behaves like a wave, at least it is not symmetric. So the photon maintains some wave properties until it is absorbed also when examined closely within the abstract geometry.

4 The Compton Particle, the Atomic Nucleus, and Quarks

The nature and origin of matter is of course *the* most important problem in physics hiding the answer to the question why there exists anything at all in the first place. This problem, emerging at the Thompson-to-Compton scattering transition, has mostly been investigated in terms of the energy equivalence of radiation and matter [33] and after the discovery of the positron, in terms of matter-antimatter, for example at the boundary of black holes [34], in terms of vacuum fluctuations [35], and in terms of the 'Big Bang' Standard cosmology. The latter entails the unsolved problem of matter-over-antimatter dominance, in the case of cosmological 'inflation' the unexplored possibility that radiation having positive energy preceded matter at the high energy densities postulated to have existed at the moment of the universe's 'creation'.

However, the matter-antimatter symmetry stems from applying special relativity to the Schrödinger equation (the Dirac equation, that is) and such 'clean' energy balance may be an oversimplification if 1) the vacuum has structure (ref [36], also discussed for the present theory in [9]) and 2) if the material particles have sub-structure, which they do have as provided by the Standard Model of Particle Physics. For example, the simplest known stable particle, the electron, has substructure in its magnetic moment. Its substructure in terms of its internal deBroglie frequency defines the Bohr radius (Eq. 7) which means that not only does it have a spin but its internal energy is structure-seeking for its most stable distribution in the atom. Furthermore the cosmological line increment *per se* entails a space-time vacuum asymmetry that has the potential of marginalizing the problem of the matter-antimatter inequivalence sought for in the Standard Model of particle physics and cosmology.

The Standard Model of particle physics characterizes matter particles in terms of transitions from higher to lower energy levels until one reaches stable matter; the electron, the proton and the latter's partner in the atomic nucleus, the neutron. These transitions, the decay of unstable particles into more stable ones, are well characterized, not in terms of matter-antimatter, but precisely in terms of the particles' internal structure - their charge, spin, color a.s.f. By necessity such experiments and the theory thereof applies to very high energy, much above that of stable matter at rest, so the task arises to evaluate which reminiscences of the various high energy transitions take place in stable matter also, if any. In trying to solve this problem one is reduced to plain theory, good luck and the hope of being able to consolidate the results by reference to a wider context, quantitatively if possible.

The discovery of two magnetic monopoles in Planck's constant (Eqs. 2 5, Fig 8) seems to be a good starting point since quarks have been theorized to be confined by two monopoles [37] [38]. Consequently, the atom having its putative mass-providing quark dynamics at the center can be viewed as two radiating monopoles of opposite charge. Since the quarks have very short range of interaction they can not be expected to interact beyond their nearest neighbors. The proton, constituted by u, d and u, is stabilized by interacting with its dual, the neutron, constituted by respectively d, u, and d.

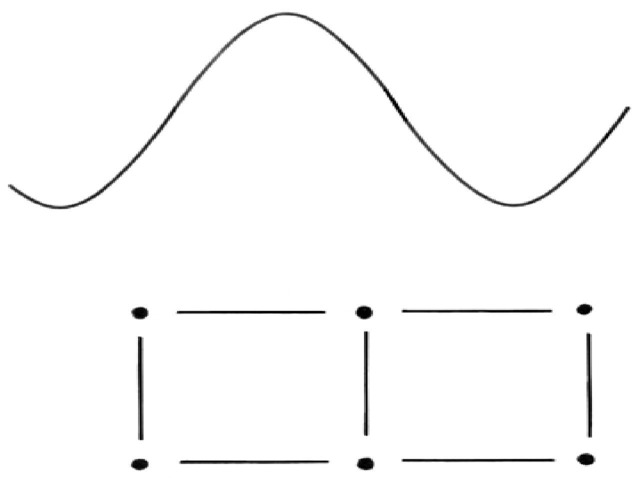

Figure 11: Illustration of quark (dots) dynamics in a hydrogen or helium nucleus, upper row of dots, the proton, has the sequence u d u, and the lower row has d u d which represents the neutron popping in and out of existence in the proton or else, a deutron. The lines connecting the dots represent gluons generically, or here W-bosons of very short duration, fractions of their duration in high energy scattering experiments. The curve in the upper part of the drawing relates to Fig. 12.

There is only one nearest neighbor-configuration of such a dynamics, the one illustrated in Fig. 11 A. Here, 1/7 of the total resonance at play in one proton is available for each quark-quark interaction. (Alternatively, in Fig. 13, the available resonance is divided by 3 as in the case of the proton and the neutron.)

Since it is known from electro-weak Z-production in proton-proton collisions that the W-boson couples to u-d pair color exchange (Fig. 1 in ref [39]) it is straightforward to assume it is capable of acting as a proxy for the gluons. In the Standard model the latter are thought to be mandatory for dynamics in higher quark symmetries than what applies to stable matter anyway. The W and the gluon have the same spin and the charge of the W-boson in comparison to the neutral gluon should actually make it better fit for interacting with the charged quarks. The W-boson is too heavy to be seen in stable matter but nothing prevents from postulating it or fractions thereof exist for much shorter time intervals than in the out-of-equilibrium proton-proton collisions. The out-of-equilibrium theories may guide but not dictate the particle dynamics of stable matter allowing some freedom of imagination. In such a case, when there are no accelerator proton-proton collisions, from where does the W or a fraction thereof get its internal energy - its equivalent mass? It has previously been shown quantitatively that it is possible to relate the masses of the resonance bosons to the apparent cosmological expansion rate [40]. However, before revisiting these calculations consider a hard ray at or above the transition between Thompson and Compton scattering where one enters the realm of matter-antimatter creation, highly relevant in this context:

Fig. 12 identifies the u and d quarks (the only ones to care about in stable matter) by their charge only, as they would label the oscillating electric field of such a hard electromagnetic wave. The electromagnetic wave (lower half) with its corresponding quark charge label (upper half) is propagating from the left in the drawing towards an observer at the right and the events in the wave proceed on

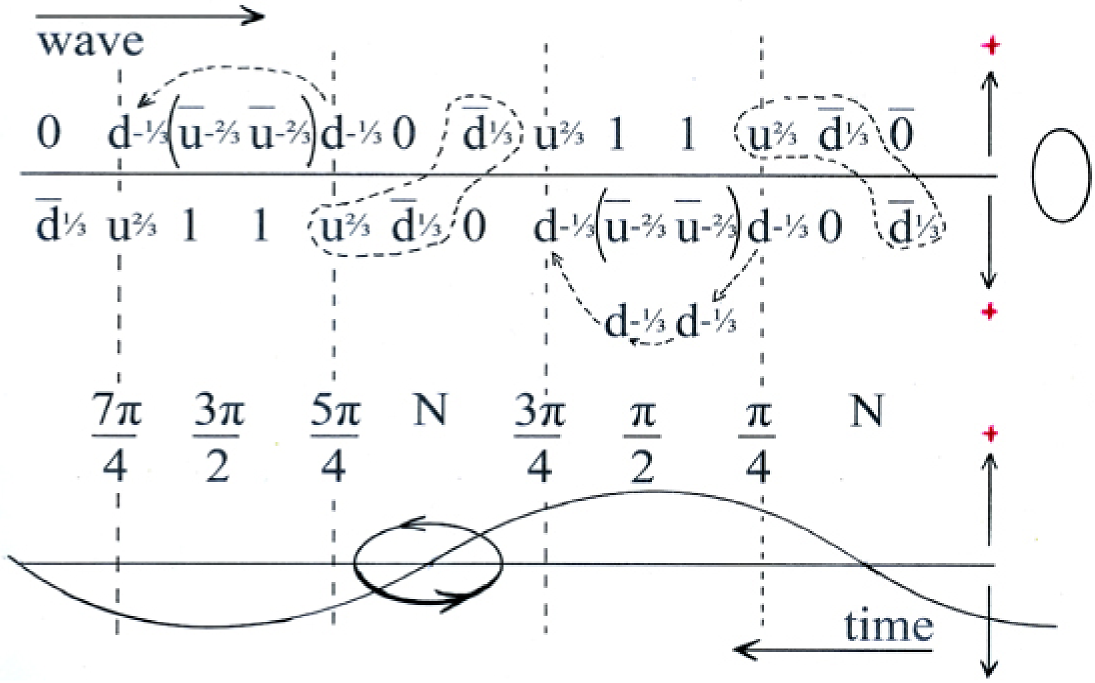

Figure 12: Illustration of quark dynamics around an axis of mean charge (upper horizontal line) hypothetically carried by an electromagnetic wave (lower half of the drawing) as described in the text. An observer to the right sequentially sees the quark events indicated starting from the non-local node at 'N'. In order to see the quark dynamics start with the charge +1/3 to the far right and follow this charge as it simultaneously oscillates to a higher value above and a lower value below the axis of means. The number '0' represents electroneutrality and '+1' a positive elementary charge. The polarization carried by the field uniquely defines the u, d, $\overline{u}$ and $\overline{d}$ quarks. The first particle seen is a π^+ pion encircled by dashed lines, calculated in the resonance example in the text to have a mass of 1.8 GeV.

a time axis extending from right to left. Hence a positive charge of +1/3 initially associated with a $\overline{d}$ antiquark to the right in the drawing will be subject to color changes above and below the charge equilibrium of +1/3 as the wave propagates. The charge oscillation is represented by red + signs (there should be four not just three of them). The quarks are taken as local and the antiquarks are taken as non-local as defined previously in this text. Then the latter interact into the future (leftward in the drawing). This is consistent with the Standard Model's perception of negative energy running on a negative time axis in the sense that an interaction from the future to present time runs backward in time. The local positive energy quarks on the other hand interact into the past (rightward in the drawing) into events just having occurred.

Two other consistencies with the present theory appear in this representation. First, the vacuum energy enters the wave at the non-local nodes where the curls attain a maximum. By Stokes' theorem such kinetic energy comes from anywhere in the electromagnetic wave and, generally speaking, from anywhere in the universe from other waves than the one illustrated. For example, as discussed previously in connection with the spiral galaxies [41], a non-local 'massive field' in equilibrium with local matter similarly to the Planck distribution consisting of energy in the field interacting with energy in matter, may participate. The second consistency in Fig. 12 with the present electromagnetic theory is that the local components, the u and d quarks appear at a phase shift of $\pi/4$ from the node where

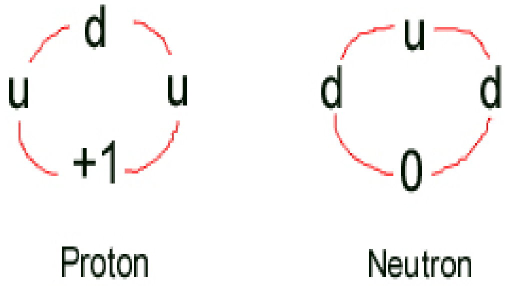

Figure 13: Illustration of quark dynamics in the proton and the neutron. The proton to the left is stabilized by its charge '+1' (cf. Fig. 12) and the neutron by its being neutral, '0'.

the acceleration of the field is maximal.

Starting from the first node at the right in the drawing a pion, $\pi^+ = u\overline{d}$, is formed (or stabilized by the electric field), its u-quark interacts towards the past with a $\overline{d}$-quark heading towards the future at phase $\pi/4$ where the field defines a u and a d quark. Subsequently ($> \pi/4$) there are two possibilities, either the d survives the antinode at phase $\pi/2$ to sustain a $u \rightarrow d \rightarrow u$ sequence of events or else, a π^--meson ($d\overline{u}$) is sustained. Either way the d reappears at phase $3\pi/4$ and interacts again with the u-quark. The phase interval $\pi/4$- $3\pi/4$ has two interesting features: 1) The u-quark may interact with the charge +1 of the proton forming a closed loop $u \rightarrow d \rightarrow u \rightarrow +1$ (Fig. 13). 2) This phase interval contains the $\overline{u}$ and d quarks which are known in the specialist literature to be involved in CP-violation in the Standard Model, notably in terms of their couplings to a W-boson in the 3×3 KM-matrix [42]. Hence, the events indicated in Fig. 12 representing stable matter at lower levels of symmetry operations than in the Standard Model decidedly bring in the W-boson as a possible real-time mass-provider as previously calculated based solely on resonance arguments [40]. Furthermore, 3) Along the entire sequence of events in the wave the pion appears as an important player at the quark level as it is known also empirically to do in the atomic nucleus, remembering that it was the first transient particle predicted; by reference to Fig. 11 the presence of the pion even hints at a mass stoichiometry since its mass 139.6 MeV (π^+), or 134.5 (π^0) is approximately 1/7 of that of the proton, 938 MeV, such that one pion would be providing mass to one u-d quark interaction (bypassing relativistic gluon dynamics). There may be room for an even better fit since the quarks are theory-sustained and some descriptions presuppose they are mass-less. Another approach to derive the masses based solely on resonance is described in the next paragraph. Furthermore, among the notables in Fig. 12, 4) the u-quarks and u-antiquarks appear repeatedly on opposite sides of the wave's charge equilibrium at the antinode intervals $\pi/2, ...3\pi/2, ...$ while the $\overline{d}$ antiquarks oscillate spatially at the nodes of the wave. At phase $3\pi/4$ the wave re-sustains its previous u quark-events while the field amplitude of charge oscillates to the other side of its equilibrium value, first interacting with the Stokes non-locality at the node, which in principle may involve a massive field[11], then again displaying a proton at the quark level. Finally, 5) a line in space pursued by the wave in Fig. 12 would produce alternately a proton and a neutron over and over again, each time with an electron being elsewhere for charge neutrality.

As for the masses involved, recall first Eq. 6 where the charge current enters squared into the material-particulate charge carrier. By analogy [40], let the cosmological line increment have two perpendicular components that enter squared into a vector current and an axial current presumed to couple to the masses of the W and Z bosons:

$$M_W = AH^2 + B_1 \pi H^2 C \tag{11}$$

$$M_Z = AH^2 + B_2 \pi H^2 C \tag{12}$$

where $M_W = 80.4\ GeV$, $M_Z = 91.2\ GeV$, $H = \Delta = 0.7714 \times 10^{-26} m^{-1} \rightarrow H^2 = 45\ GeV$ and A, B, C are constants to be identified. Subtracting 12 from 11,

$$\Delta M_{W-Z} = \Delta B \pi H^2 C. \tag{13}$$

The left function variables in the first two equations represent vector currents and the right ones axial currents the latter ones scaled to the first ones by the factor π so that the processes of interest take place in the framework of the Z boson. Accordingly, the axial factors to the right are further adjusted by the weak mixing angle θ so that $C = sin^2\theta = 0.229$. Then resonance can be established for some choice of the variables A and B being integers or quotients of integers, for example $A = 1.71$, $B_1 = 1/9$, $B_2 = 4/9$, and $\Delta B = 1/3$. Applying these values to Eq. 13 yields the result that the energy equivalent of the loss of mass following the $W \rightarrow Z$ transition, 10.8 GeV, resides in the apparent Hubble rate where it is divided by $1/\Delta B = 3$ such that resonance occurs at 3.6 GeV. In Fig. 12, the resonance takes place twice per cycle at the nodes so the number of interest is rather 1.8 GeV. There actually exists a pion having this mass, the $\pi(1800)$ at 1812 MeVwhich would be able to pump approximately half its mass into the out-of-resonance proton at 0.938 GeV both particles oscillating in their proper phases shown in Fig. 12. In this context it is also relevant that the quotient 3.6/80.4, its numerator just shown to possibly sustain the matter in the universe, is 0.045, which is the proportion of baryonic matter in the universe in Standard Cosmology. Consequently, it is natural to think of a massive field remainder of the W-boson linked to the apparent cosmological expansion rate, cf. [41].

Then turn to the numerical value of the geometrized permittivity of space in Eq. 6, 2.752×10^{-5} and compare with the electron over proton mass quotient $M_e/M_p \times \frac{1}{2\pi^2} = 2.759 \times 10^{-5}$. It differs by just a quarter of a percent and the magnitude is right. Is this a coincidence? In physics much better accuracy is expected in general but in the history of the discipline rough estimates have sometimes been accepted in anticipation of knowledgeable corrections if they fit a theory well from the beginning. First of all the factor $1/2\pi^2$ needs to be explained here. In principle, multiplying with a π bends a straight line around a point and dividing by π straightens out an arc. In Eq. 6 there are now two composite factors on the left side,

$$\frac{M_e}{2\pi^2\ M_p}\quad \Delta^2\pi\ ,$$

and the factor π^2 may be associated with any of them. Consider first the right side of Eq. 6, which has two perpendicular currents on the surface of a sphere. The right factor above may be interpreted as the surface of a sphere but the geometry (Appendix) prescribes that the momentum frame is a straight line. Therefore, if one assumes that the perpendicular elementary currents, $e\pi/s$ are congruent with currents flowing on $\Delta^2\pi$, which just have been linked to quark dynamics and matter, it is

[11] in the atomic nucleus, or, at the transition where electromagnetic radiation starts to behave as particles

possible to justify dividing by π^2. Another possibility is to use the hypothetical relation [9] between the Bohr radius and the proton radius linked to neutron scattering (not the proton's charge radius, that is) and plainly substitute π from (m=SI unit meter)

$$\frac{a_0}{\pi \ m} = \frac{\pi \overline{\Delta q}}{r^p} \quad \rightarrow \quad \pi^2 = \frac{a_0 \ r/p}{m \ \overline{\Delta q}}$$

If so, the mass quotient M_e/M_p turns into a one-dimensional mass density quotient. (A somewhat better numerical agreement can be obtained by using the quotient $M_e/(M_e+M_p)$ for M_e/M_p). Whichever way to deal with π one prefers, the implications of the end result

$$\epsilon_{(0,G,e)} \approx \frac{M_e}{M_e + M_p} \frac{1}{2\pi^2} \tag{14}$$

are compelling. First of all, the numerical agreement corroborates the other numerical results in this Chapter indicating that $\Delta^2\pi$ is a vacuum contribution to matter since the terms occur together in Eqs. 6 and 14 and the permittivity of vacuum is known to be a property of vacuum. Of course, the electron is already known to spread in vacuum as a matter wave but additionally it appears from Eq. 14 that the vacuum always has a niche for the electron even in its absence and that this niche is employed by electromagnetic radiation when it relies on the permittivity of space. Hence, the vacuum has structure linked to the type of matter it is capable of harboring.

Such far-reaching conclusions may seem premature on the basis of a numerical approximation but the least one can say is that if the charge had been geometrized too as it is done in various 'natural' geometries, then the numbers would have been lost in abstract ambiguities. Whereas a textbook always is perfect (but may be wrong) the frontiers of science are never perfect (but may be right). Therefore, the results presented herein should perhaps be regarded as a platform from where to perceive new horizons and rethinking old science problems. Why not, for example, consider from Eq. 6 that the quark dynamics is a whispering gallery resonance phenomenon, cf. [43], on the surface of the atomic nucleus where it, as in Fig. 12, is linked to particle-antiparticle creation at a boundary like in a black hole [34] or that particle creation in the universe takes place, not in a big bang singularity transcending the laws of Nature, but where there is linear hard radiation sustaining protons and neutrons (Fig. 12) with charge separation due to magnetic fields (jets of galaxies and quasars)? The transition where hard radiation starts to behave as matter particles, cf. [30], tentatively described here in terms of quark dynamics (Fig. 12), is also interesting from the point of view of alternative approaches to fusion reactors .

5 A Historical Perspective

This paper started as a search for the photon in electromagnetic radiation but turned into a consolidation of the structure of matter in the form of the primordial hydrogen atom and a last resort venture to find the Compton particle in the factors $\Delta^2\pi$. The ambiguous nature of the photon quantum-particle noticed in humanities (language-philosophy [44]) could be confirmed by demonstrating reminiscences of light's wave properties in the present and other theoretical descriptions of the light particle. Instead of confirming the existence of the photon the investigation lead to the discovery of the footprints of the gate-keepers of science through more than a century. First of all, their ignorance of a kinetic component in the wave-description of radiation filling in the void at the wave's node and the usefulness of the concept of Stokes curl to obtain an intuitive understanding of non-locality in the wavefront and in the electron cloud. Then the indivisibility of Planck's constant underpinning the quantum concept of light even though the constant in fact can be factorized to yield the physical meaningful result that if there is a light quantum it appears in the light-matter interaction. And last but not least the still prevailing SR preventing from seeing the dynamics of the electromagnetic radiation and held the 'natural' geometry even though it denies non-locality and ignores the cosmological line increment. The 1920:s must have been an exciting time for the gate-keepers of science looking for use of deBroglie's electron vibrations, Compton's momentum, the Hubble expanding universe, emerging quantum physics, and Bose statistics. Perhaps their preferences and omissions can be better understood from the perspective of contemporary theoretical cosmology where many are motivated and rewarded by trying to show that GR is right rather than solving the fundamental problems. This leads to the famous absurdities of the Big Bang theory; the 10^{120}-fold misfit of vacuum energy, the invention of the speculative dark matter - dark energy straightening out advanced calculations gone wrong, all of the universe once having resided in a mysterious point singularity that transcends the rules of known science, the problem of the boundary of the universe and what is beyond, the large scale structures observed in the universe purportedly resulting from a 'BANG', the mismatch of measured and theory-sustained Hubble constant, and finally, all of the energy of the universe including its matter claimed to be just a tiny little fraction remaining from matter-antimatter annihilation not even asking what had been before. How is it possible that advanced scientific research could have gone this wrong that even an elementary school education would suffice to notice some errors made and the tricks to straighten them out? Perhaps the answer lies in the culture of academic publishing where anything that has passed is regarded as established even though it is often just evidence that a few who know less about the subject than the author have approved it.

These problems started with Eq. 2 in [6], which, judging from its witness, Eq. 0, p. 483, l. 10 in [6] and the aftermath, effectuated a well prepared physical coup d'état bringing many in attention to the rules and regulations sustaining SR, subsequently evolving into GR. However, one can learn from the history of black-body radiation in science that even quantitative descriptions may be ambiguous. Here, the same equation, which accurately describes its relevant phenomena is derived in i.a. the various frameworks of molecular oscillators, Bohr energy levels, the statistically most probable distribution of quanta, radiation in equilibrium with molecules or an electron gas, and particle creation at an event horizon[12]... So why should Eq. 9 be taken to support SR or the photon concept even

[12]for literature references see [45]

though it was derived from Eq. 2 in [6] especially after having outsourced Eq. 0 in [6] to the perilous environment of [3] where the electron dynamics explains the wavelength shift of the scattering? And why should one believe in GR and its disastrous cosmological consequences enumerated above knowing that [46] it constitutes a simplification of tens of equations, from the beginning keeping only those that fit, and that its Riemann curvature, a mathematical generalization of Stokes curl, is used for the purpose of describing locality-gravitation turning the very gist of the Stokes curl into its opposite. It seems that indirectly restoring non-locality by using its proxy, rotation, can solve at least the dark matter problem of GR [47] but was it necessary to spirit away the concept of non-locality in the first place? The least one can say as a non-expert is that GR surely seems to have a component of shaman magic. -What really happened behind the scenes in the 1920ies when the implications of Compton's and deBroglie's work were evaluated by the scientific community has had profound impact in physics still 100 years afterwards still creating impasses.

References

[1] G. N. Lewis (1926) The conservation of photons. Nature 118 (2981) 874-875

[2] M. H. Johnson and E. Teller (1982) Intensity changes in the Doppler effect. Proc. Natl. Acad. Sci. USA 79, 1340

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

[4] L. deBroglie (1987) Interpretation of quantum mechanics by the double solution theory. Annales de la Fondation de Louis de Broglie 12, 1-23

[5] wikipedia.org 'Photon' article 2020

[6] A. H. Compton (1923) A quantum theory of the scattering of X-rays by light elements. Phys. Rev 21 (5) 483-502

[7] 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

[8] E. Cerven (2003) Space-time dimensionality of plain physical observation Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology 2. Note: The author's items in this reference list are mostly unedited with some known errors remaining.

[9] E. 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 No. 27

[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] T. Salzburger, P. Domokos and H. Ritsch (2005) *Theory of single-atom laser including light forces* www.arxiv.org quant-ph/0504094v1

[12] U. Kraus (1999-2000) Brightness and color of rapidly moving objects: The visual appearance of a large sphere revisited. Am. J. Phys 68(1) 56-60

[13] R. Becker F. Sauter (1959, 1963) Theorie der Elektrizität. Erster Band., p. 250. B. G. Teubner Verlagsgesellschaft, Stuttgart

[14] O Chwolson (1926) Die Physik 1914-1926. Siebzehn ausgewählte Kapitel. Friedr. Vieweg & Sohn Akt.-Ges. (Braunschweig)

[15] E. Cerven (2003) Calculation of cosmological observables from constants of nature. Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology No 1; (2004) Factorization of the Planck length in terms of a line increment of the order of Hubble's constant and magnetic charge Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology No 3

[16] Y. D. Sergeyev (2017) Numerical infinities and infinitesimals; Methodology, applications, and repercussions on two Hilbert problems EMS Surv. Math. Sci. 4(2), 219-320 DOI 10.4171/EMSS/x

[17] R. Geroch (2013) General Relativity. 1972 Lecture Notes. Minkowski Institute Press, Montreal, Quebec http://minkowskiinstitute.org/mip/

[18] T. J. A. Wolf, D. M. Sanchez, J. Yang, R. M. Parrish, J. P. F. Nunes, M. Centurion5, R. Coffee3, J. P. Cryan, M. Ghr, K. Hegazy, A. Kirrander, R. K. Li3, J. Ruddock, X. Shen, T. Veccione, S. P. Weathersby, P. M. Weber, K. Wilkin, H. Yong, Q. Zheng, X. J. Wang, M. P. Minitti, T. J. Martnez (2020) Imaging the Photochemical Ring-Opening of 1,3 Cyclohexadiene by Ultrafast Electron Diffraction. arXiv.org 1810.02900

[19] S. Baskal, Y. S. Kim and M. E. Noz (2017) Photons in the quantum world. ArXiv:1711.09210v1 [quant-ph]

[20] M. Piccardo *et al.* (2020) Frequency combs induced by phase turbulence. Nature 582, 360-364, see also https://phys.org/news/2020-06-turbulence-frequency-small-lasers.html

[21] www.wikipedia.org 'Fine structure constant'

[22] V. Venugopal and P. S. Bhagdikar (2013) de Broglie wavelength and frequency of scattered electrons in the Compton effect. Physics Education 29. 35-41. (2012) arXiv.org 1202.4572

[23] A. G. Riess et. al. (2016) A 2.4

[24] A. G. Riess et. al. (2018) Milky Way Cepheid standards for measuring cosmic distances and application to Gaia DH2: Implications for the Hubble constant www.arxiv.org, 1804:10655v2 [astro-ph.CO]

[25] S. Birrer et. al. (2019) HoLiCOW - IX. Cosmographic analysis of the doubly imaged quasar SDSS 1206+4332 and a new measurement of the Hubble constant. MNRAS https://doi.org/10.1093/mnras/stz200

[26] S. Nadathur, W. J. Percival, F. Beutler, and H. A. Winther (2020) Phys. Rev. Lett.124, 221301-https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.124.221301

[27] www.wikipedia.org Article on 'Photons'

[28] E. Cerven (1999) A quantization of space-time which inherently yields the Planck energy distribution. 6:th International Wigner Symposium (lecture)

[29] D. Yu, G. L. Kotkin and V. G. Serbo (2005) Polarization effects in the non-linear Compton scattering. www.arxiv.org hep-ph/0501263v1

[30] Y.V. Radeonychev, V.A. Antonov, F.G. Vagizov, R. N. Shakhmuratov & Olga Kocharovskaya (2015) Conversion of recoilless γ-radiation into a periodic sequence of ultrashort pulses in a set of dispersive and absorptive resonant media. arXiv:1501.00394 [physics-optics]

[31] F. Sauter (1931) Über das Verhalten eines Elektrons im homogenen elektrischen Feld nach der relativistischen Theorie Diracs. Zeit. F Physik 69, 742-764

[32] G. V. Dunne (2012) The Heisenberg-Euler effective action: 75 years on. arXiv:1202.1557v1 [hep-th]

[33] F. Hasenöhrl (1904) Zur Theorie der Strahlung in bewegten Körpern. Ann. d. Phys. 15, 344- available *via* http://de.wikisource.org

[34] S. W. Hawking (1975) Particle creation by black holes. Commun. Math Phys. 43, 199-220

[35] H.B.G. Casimir (1948) On the attraction between two perfectly conducting plates. Proc. Kon. Ned. Akad. Wetensch. B51, 793-795

[36] G. K. Savvidy (2020) From Heisenberg-Euler Lagrangian to the discovery of Chromomagnetic Gluon Condensation arXiv:1910.00654v3 [hep-th]

[37] K.-I. Kondo, S. Kato, A. Shibata and T. Shinohara (2014) Reformulations of the Yang-Mills theory toward quark confinement and mass gap arXiv:1412.8008v1 [hep-th]

[38] Y. M. Cho (2012) Dimensional Transmutation by Monopole Condensation in QCD arXiv:1206.6936v2 [hep-th]

[39] The CMS Collaboration (2020) Measurement of the cross section for electroweak production of a Z boson, a photon and two jets in proton-proton collisions at $\sqrt{s} = 13\ TeV$ and constraints on anomalous quartic couplings. arXiv:1002.09902v1 [hep-ex]

[40] E. Cerven (2004) Evidence of resonance between the W-boson and the apparent cosmological expansion rate Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology # 4

[41] E. Cerven (2018) How the Planck distribution could once again turn a page in physics by addressing instant communication and the dark matter enigma as a Hubble field of vacuum energy. Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology # 23

[42] Particle Physics Booklet 60th Anniversary (2018) http://pdg.lbl.gov

[43] O. Kfir, H. Loureno-Martins, G. Storeck, M. Sivis, T. R. Harvey, T. J. Kippenberg, A. Feist and C. Ropers (2020) Controlling free electrons with optical whispering-gallery modes. arXiv.org 1910.09540

[44] N. W. Lima, B.B de Souza, F. O. Stermann, C. J. De Holanda Cavalcanti (2018) A metalinguistic study on the photon interpretation present in physics textbooks approved in PNLDEM 2015: Elements for a symmetric sociology of science education. Revista Brasiliera de Pesquisa em Educacao em Ciencias. https://doi.org/10.28976/1984-2686rbpec2018181365 https://tst08.lcc.ufmg.br/seerufmg/migracao/copiaproducao/index.php/rbpec/article/view/4874

[45] E. Cerven (2005) The first arbitrary event. Proceedings of www.scienceandresearchdevelopmentinstitute.com, Quantum Physics and Cosmology # 5

[46] A.S. Eddington (1923, 1975) The Mathematical Theory of Relativity. Chelsea Publishing Company, N.Y., Univerity Press, Cambridge. Ch. 38

[47] O. Gron T. Jemterud (2016) An interesting consequence of the general principle of relativity. Eur. Phys. J. Plus 131, 91-93; DOI 10.1140/epjp/i2016-16091-9

6 Appendix

The instant of observation has a special significance in the quantum world since it accommodates the processes that cause the quantum observer to change from the ignorant state to the observed state. One approach to characterizing the instant of observation is to perform a Lorentz transformation of the inverse of the number-flux vector at discrete time coordinates −1 and 0 defining an interval of observation:

$$(q_0, t_0) = \left(\frac{\sqrt{1-\frac{v^2}{c^2}}}{v}\frac{m^2}{s}, 0\right); \qquad (\overline{q}_0, \overline{t}_0) = \left(\frac{1}{v}\frac{m^2}{s}, -s\right) \tag{15}$$

$$(q_r, t_r) = \left(\frac{\sqrt{1-\frac{v^2}{c^2}}}{v}\frac{m^2}{s}, s\sqrt{1-\frac{v^2}{c^2}}\right); \qquad (\overline{q}_r, \overline{t}_r) = \left(\frac{1}{v}\frac{m^2}{s} - vs, 0\right) \tag{16}$$

$$\overline{\Delta q} = -vs\ , \qquad \overline{\Delta t} = \overline{t}_r - \overline{t}_0 = s \quad \Rightarrow \frac{\overline{\Delta q}}{\overline{\Delta t}} = v \tag{17}$$

$$\Delta q = 0\ , \qquad \Delta t = t_r - t_0 = s\sqrt{1-\frac{v^2}{c^2}}\ . \tag{18}$$

Here, m is the unit of length and s the *geometrized* unit of time [13]. This system of equations defines two observers located at origo (un-barred) and at radius distance from origo (barred observer). The latter observer is capable of observations along the momentum axis, $\overline{\Delta q}$, and of measuring the unit of time while the observer at origo only is aware of time and recognizes an angular velocity v. The two observers are space-like separated.

The directions of the axes is defined by analogy with the unit circle, $(\cos x)^2 + (\sin y)^2 = 1$, as

$$q_r{}^2 + \frac{1}{c^2}\frac{m^4}{s^2} = \frac{1}{v^2}\frac{m^4}{s^2} = \overline{q}_r{}^2 \tag{19}$$

or

$$(\frac{\Delta t}{s})^2 + (\frac{\overline{\Delta q}}{m})^2 = 1 \tag{20}$$

so that line increment and time interval are perpendicular. The time interval measured by the momentum observer is also perpendicular to the momentum frame where it defines the tangential velocity as shown in eq. 17c.

The sign of the line increment (cf. eq. (17) shows that the radius of the observed object decreases. This corresponds to the observer at origo computing a contracted radius $\overline{q}_0$ similarly to the Fitzgerald case, $q_0 = \overline{q}_0\sqrt{1-v^2/c^2}$. Hence, the geometry can be understood as a circle space-like separated from a peripheral observer who detects it in the form of a line increment in the direction of observation (equivalent of a contraction of its radius) after the passage of one unit of time. Furthermore, the axis of linear momentum may also be thought to harbor axial vectors. In physics, line increments in the direction of observation are known from the Bohr atom and the cosmological expansion.

For observations towards origo along the radius, the magnitude of the line increment is amplified from $\overline{\Delta q}$ per unit radius to the unit length, m (this may also be seen from eq. (15b) and (17a)),

[13] using non-standard (not SI) notation for the purpose of distinguishing the two units

$$\frac{-\overline{\Delta q}}{m} = \frac{m}{\overline{q}_0} \quad , \tag{21}$$

which yields

$$\overline{q}_0 \, \overline{\Delta q} = -m^2 \approx \overline{q_r} \, \overline{\Delta q} \quad , \tag{22}$$

whereby the velocity of light, m/s, limits the radial extension of the geometry to $|\overline{q}_0|$ ($v \leq c$ as required by $\sqrt{1 - v^2/c^2}$). Because of eq. (17) and (18), observations can only be made from the laboratory frame at the periphery towards the origin of space and time coordinates. The observer at origo is non-local in the sense of performing all observations solely on the time axis (eq. (18b)) and can only access the observation *via* eq. 20.