Two Worlds in One - New Physics on Old Pillars *

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Abstract

Ampère-Maxwell's law, Faraday's law and the Lorentz force are rewritten in terms of a geometry comprising two perpendicular frames of observation, a longitudinal momentum frame and a transverse frame which is non-local as judged by the momentum observer. This is made possible by the use of the vector potential in the Coulomb gauge in place of the electric field and by recognizing the vectorial nature of time, which is made transverse to the momentum frame. As a result, quantitative interpretations of physical processes taking place in both frames of observation can be made. The general methodology is outlined of reinterpreting physical processes as visible to a local observer and inferred by a non-local observer. Hereby the vector product acquires a physical role in its capacity of transferring an entity into another frame of observation. The De Broglie equation is finally cast in a form consistent with the special geometry adopted, corroborating previous calculations indicating that the mono-baryonic atom is the natural matter quantum of the universe.

Keywords: Electromagnetic radiation , Waves , Matter waves , Ampere-Maxwell's law , Lorentz force

1 Introduction

Physics provides many examples that a phenomenon may be interpreted in several different ways that all lead to a quantitative description in terms of some equation comprising measurable variables. A very multifaceted such example is the black body radiation, which has been interpreted through the years in terms of classical thermodynamics, quantum jumps between electronic levels of excitation, the most probable distribution of quanta, radiation in equilibrium with an assembly of molecules or electrons, black hole geometry, decoherence, and probabilities of permissive and consequential events [1] [2] (see [1] for historical references). Another example is the Lorentz force, which has been derived based on Maxwell's equations [3], special relativity theory [4] and dispersion theory [5]. A third example is provided by matrix mechanics *versus* wave mechanics.

These examples suggest that an abstract and comprehensive interpretation of any concrete physical phenomenon may turn out to be a fallacy even though it is quantitative. Such ambiguity regarding interpretation is prone to level scientific descriptions of nature to that of other disciplines, like for example philosophy, and to introduce an element of arbitrary opinion into the equations. At the

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other extreme one may try and establish a quantitative description that is independent of molecular or physical mechanism, as has been done successfully for thermal radiation [6] and relinquish the hope of accurately interpreting the physical process that really takes place.

At any rate, the examples given above show that several different interpretations may lead to an equivalent correct description of the real world. Having arrived at the successful *description* in one manner does not preclude that another *interpretation* may yield the same result in the future. At that point of time it is appropriate to discuss which interpretation may be correct. Against this background recall the 'Bohr-Dirac Universe' [7] [8] [9] wherein the apparent cosmological expansion rate, the age of the universe and its baryon density derived from a line increment factorized out of the Bohr atom's ground state agree numerically with values obtained in standard Big Bang cosmology. In addition, the previous work provides a verifiable geometry, reminiscent of the Dirac string, to the universe including all its constituents [9] [10] [11] [13]. The present paper aims to find the appropriate context of these results by reference to other investigations, and to expand its applicability to include electromagnetic radiation.

2 Results

Most physical descriptions of the real world start with the assumption that its geometry is that which an intelligent observer can deduce based on daily life activities. Hence, the Cartesian coordinate system comprising 3 spatial axes later modified in relativity theory to include a temporal axis are thought to be a suitable framework for most physical descriptions. However, the matter components of the real world do not have the privilege to take such a grand perspective. Their fate is to either interact with or to ignore other constituents of the real world. In the process of so doing they form viable elements of increasing complexity in ever higher hierarchies until at some level intelligent life appears [14] [15]. A very firm characteristic of the interaction is that it defines an interval of time [14] [15], the moment when it takes place, whereupon the matter element, ignorant, awaits the next influence from the surroundings. The moment of observation, which defines present time, is a fundamental property of all quantum physical processes. To exist in the frame of present time remains a requirement for making an observation across all complexities and hierarchies even including intelligent observers. A valid geometry of the real world must account for these facts. It must comprise an implementation of the outstanding uniqueness of the observer's frame of present time.

Table I. Frame signatures of various classical measured or related entities in terms of the present theory. Entities marked with a bar ($\overline{\ }$) are presumed to be visible to the quantum observer while those marked with a tilde ($\widetilde{\ }$) are not. The latter may instead be reckoned by a yonder (non-local) observer. Using the rules $\overline{\ } = \widetilde{\ }\,\widetilde{\ }$ and $\widetilde{\ } = \overline{\ } / \widetilde{\ }$ two alternative, equivalent signatures are indicated in the two columns at the left of the named entities. In the four columns at the right, the effects on the signatures by operating with t^{-1}, m^{-1} (or gradient, ∇; m = meter), the vector product ($\nabla\times$) and the scalar product ($\nabla\bullet$) are indicated. The classical entities fall into 8 groups of identical signature. Those belonging to Group A and B can be unambiguously interpreted in terms of the present two-dimensional theory whereas the composite ones, e.g. Group C and D, can not. A composite entity may be transferred to the local ($\overline{\ }$) or yonder ($\widetilde{\ }$) frame using the vector product as indicated in the first and third columns to the right or by factorizing in a material constant, indicating that the classical notation either needs revision for the present purposes or that it indicates a physical process. In the case of the various densities, the physicality of which is not evaluated here, the notation $\odot$ is used for dividing by local length (m) while $\otimes$ is used for a possible equivalent length in the yonder frame. The notation $\widetilde{\nabla x}$, applicable to Group A, B, E, and F is used for $1/\partial t$ for reasons explained in the text.

Table I

( )	⇔ Signature	Unit	t^{-1} ($\partial t^{-1}, \widetilde{\nabla\times}$)	m^{-1} (∇)	$\nabla\times$	$\nabla\bullet$
(‾/ ∼)	∼	Group A:	1	∼/ _	∼	0
		Time (s)				
		Mass (s (kg → s))				
		Electric Charge (C)				
		Electric Polarization, P (C)				
		Force (N)				
		Velocity, c, v				
		(Magnetic) Vector Potential, A				
(∼∼)	‾	Group B:	∼	1	0	_
		Length (m)				
		Momentum, $\hbar k$ (kgm/s → m)				
		Power (W)				
		Resistance (Ω)				
		Magnetic Charge ($\overline{C}$)				
		Electric Potential (V) (quantity of charge)				
		Scalar Potential (V)				
(‾ ‾/ ∼)	∼∼∼	Group C:	‾	∼		
		Energy (J)				
		Magnetic Flux ($Wb = V \times s$)				
		Magnetic Flux Quantum, $\hbar/2e$				
		Electric Dipole Moment (C m)				
		$G = c^3$ (kg → s)				
(∼/– –)	1/ ∼∼∼	Group D:	1/– –	∼/– – –		
		⊙ Energy Density (Volume = ‾)				
		⊙ Electric Flux Density (C/m^2)				
		⊙ Electric Displacement, D (C/m^2)				
		⊙ Polarization Density (C/m^2)				
		Pressure ($Pa = kg/m^2,\ kg \rightarrow s$)				
(∼/ _)	1/ ∼	Group E:	1/ _	∼/ _ _		0
		Frequency (Hz)				
		⊙ Magnetic Flux Density ($T = Wb/m^2$)				
		⊙ Magnetic Field Strength, B ($T = Wb/m^2$)				
(1/ ∼ ∼)	1/ _	Group F:	∼/ _ _	1/ _ _	0	
		Magnetic Field, H (A/m)				
		Magnetization Density (A/m)				
		⊙ Intensity (VA/m^2)				
		⊗ Electric Charge Density, Volume ∼				
		⊗ Mass Density, Volume ∼				
		⊙ Poynting Vector (W/m^2)				
		Wave Number ($2\pi/\lambda$)				
		∇ , $\nabla\bullet$, $\nabla\times$				
(‾/ ∼∼)	1	Group G:	1/ ∼	1/ _	n.a.	n.a.
	mixed	Acceleration				
	yonder	Current (A, C/s)				
	yonder	⊗ Energy Density, Vol ∼				
	local	Electric Field Strength (V/m)				
	yonder	Electric Field Strength ($\partial A/\partial t$)				
	1/ _ _	Group H:	∼/ _ _ _	1/ _ _ _		
		⊙ Electric Volume Current Density, $\boldsymbol{j}$ (A/m^2)				
		⊙ Magnetic Charge Volume Density ($\overline{C}/m^3$)				
		∇^2				
		Material Constants:				
	∼	Permeability, $\mu,\ \mu_0$ (H/m)	‾/ ∼			
	1/ ∼∼∼	Permittivity, $\epsilon,\ \epsilon_0$ (F/m)	∼/– –			
	1/ ∼	Capacitance (F)	∼/ _			
	1/ _	Conductance	˜/ ∼ ∼ ∼			
	∼∼∼	Inductance (H)	‾ ‾/ ∼			

One approach is to define a momentum frame which is devoid of a time axis to the effect that any time interval inferred by the local observer may be regarded as perpendicular to his frame [10] [11]. The geometry used here is obtained by Lorentz-transforming the inverse of the $\overline{x_1}$-component of the four-velocity at time $\bar{t} = -1$ and $\bar{t} = 0$, representing an interval of observation. This yields two space-like separated observers, one peripheral (relative to origo) who measures a local line increment along a one-dimensional momentum axis and the other at origo, who infers a distant rotational velocity. Since the line increment per unit time and the velocity are numerically equal and help define the geometry any changes of these instantly transform the whole system comprising both observers. The perpendicular frame is inaccessible for observations as seen from the momentum axis and therefore may have arbitrary direction as evaluated from the momentum frame. Thus, it may be regarded as 'non-local'. These conclusions are somewhat similar to the case of some representations of the Galilei group where a non-local particle may locate with equal probability at origo and the circumference of a sphere [12]. In the present case, entities which are amenable to observation are denoted by a bar over the unit or symbol (e.g. $\overline{m}$ and $\bar{p}$ for 'meter' and momentum) whereas those that are not are marked with a tilde (e.g. $\tilde{t}$ for time). The rules $\tilde{}\tilde{} = \bar{}$ and $\bar{}/\tilde{} = \tilde{}$ are established with the requirement that any symbol equation should be balanced on the left and right hand sides with respect to such a 'frame signature'. Then, for example, $\bar{p} = M\tilde{v} \Rightarrow \bar{p} = \widetilde{M}\tilde{v}$, mass is assigned to the inaccessible (yonder) frame.

Since all SI-units are either basic or derived from basic ones (e.g. [16]) the frame signatures of various physical units are easily obtained as shown in Table I (improved with respect to Table I in ref. [17]). This Table will subsequently be helpful in examining the nature of physical processes. Actually, distinguishing between longitudinal and transverse frames has some background in physics, starting from the discovery that light's electric and magnetic fields are perpendicular to its propagation direction. Since the wavefront penetrates refractive materials with unchanged velocity [18] and light has a maximal and constant velocity it became clear that all material influences on the light ray in dispersive media would have to act perpendicular to the propagation direction [19]. Thus electromagnetic radiation accommodates naturally a geometry where transverse and longitudinal frames have distinct physical roles. This provides an important clue to the geometry of the real world.

3 Electromagnetic Radiation

The first thing that one notices when trying to apply the frame signatures in Table I to Maxwell's equations is that the electric field, E, appears to be dimensionless, possibly hiding a physical process or mathematical operation of the type $\tilde{}/\tilde{}$ or $\bar{}/\bar{}$. Furthermore, the vector operator, $\nabla\bullet$, appears to act on a scalar, $\nabla \bullet E = 0$, which is discomforting. When examining the displacement, for example $\nabla \bullet D = 0$, the vector operator acts on an entity which appears to be composite in terms of frame signature. Since it is desirable to find the simplest description of electromagnetic radiation in terms of the geometry reflected in Table I the use of the electric field must be abandoned, a quite dramatic conclusion considering the importance of the field concept in general in modern physics. However, the field can be decomposed into scalar and vector potentials,

$$E = -\overline{\nabla\Phi} - \frac{\partial \widetilde{A}}{\partial \tilde{t}} \tag{1}$$

which are well-behaved in with respect to frame signature as indicated by notations $\bar{}$ and $\tilde{}$. Here, the factors Φ and A contain seeds of dynamics since the signatures indicate displacement on respectively the longitudinal and transverse axis. In Eq. 1 one notices that the vector potential is perpendicular to the momentum frame, which is not the case in the classical Lorentz-invariant case where it is distributed among three spatial axes including the momentum axis. However, in the present geometry one is interested in measurable processes taking place on the momentum axis and a potential *per se* is not such a physical process. Neither is 'force' *per se* a detectable physical process, which is the reason it is found in the yonder frame (cf. Table I, Group A). Even independent of theoretical model it may not be quite justified to demand Lorentz-invariance in the general case, for the following reasons.

Does a law of nature really have to be relativistically invariant to be correct? Or, in other words, if an observation has been made in one selected Lorentz frame is it necessary to invoke all other frames at the same time in order to make the observation permissible? In quantum physics such a selection and choice based on statistical probabilities of states precedes the observation. A related problem in four-dimensional space-time exists on the cosmological scale as to whether the choice of epoch in which to make an observation should comprise other epochs as well (including future ones). If such invariance were to exist the world would be very deterministic and any apparent 'choice' would be fiction. There seems to be no statistical justification for demanding invariance of frame or epoch based on current knowledge, especially when one considers the quantum mechanical fact that a signal perceived in one frame of observation makes all other frames ignorant of that signal. Studies on entangled partially relativistic systems might clarify this point. A funny perspective on RT can be achieved by imagining that it had been developed by a society of earthworms. These perceive vibrations and would have set the maximum signal velocity at that of sound. They would not have been aware of light signals, in principle. Since RT was developed by humans they set the maximum signal velocity at that of light, which is a tautomerism since a signal is implied to mean a light signal and light, as is well known, has a certain absolute velocity. Other means of information processing besides that of the photon momentum might be found in rotating systems where phase shifts are equivalent along the radius and may occur instantaneously. Furthermore, just like the number 0 is inert on addition and the number 1 is inert on multiplication adding a velocity v to that of light, c, in relativity yields c again. By performing the identity operations $0+$, $1\times$, and $v+$ the entities acted upon by definition remain the same so a lot of useful information about them should be lost. Clearly, a relativistic perspective on c is not the right approach to take unless one wishes to cancel it out of consideration. Similarly, focusing on simultaneity in RT (the frame of proper time that is) causes one to neglect the unique role of the observer's present time relative to all other time coordinates. Actually, SRT, as is well known, emphasizes present time in the remote, observed frame, its proper time, from where factual events are more or less distorted by various transformations until the information about them reaches the various observers. All available evidence however indicates that it is not any of the remote observed frames that merits such a unique standing with respect to time coordinate but conversely, the observer's frame. The observer's frame of present time is unique in comparison with all other frames since it is required for making an observation, a robust physical fact that demands attention. To the above logical arguments may be added the Schrödinger equation, which shows that it is indeed possible to avoid the fallacy of perfection with regard to RT when finding physical laws. Since $\overline{\nabla} \bullet \widetilde{A} = 0$ one seems to be restricted to the Coulomb gauge in the following.

Eq. 1 shows that not all descriptions of electromagnetic radiation are suitable for the present purposes. An overview in [20] refers to 8 alternative descriptions to chose between already 70 years ago [21] a situation that continues to confuse to this day for example with regard to the Poynting vector [20] [22] [23] [24] or symmetry requirement [25]. Any equation may be a quantitative description but only an equation that unaltered describes a presumed physical process is a quantitative interpretation. It is desirable to find such an interpretation among the many descriptions while benefiting from the restricted possibilities imposed by the geometry in [10] [11] as indicated in Table I. Furthermore, in the general case there is *a priori* no justification for interpreting a mathematical operator as a physical process but in the present geometry the vector products represent that an entity is shuffled between two perpendicular orientations which may imply a physical process if there is a shift of frames involved. An online presentation of the classical case of electromagnetic radiation [26] became a starting point for the present investigation.

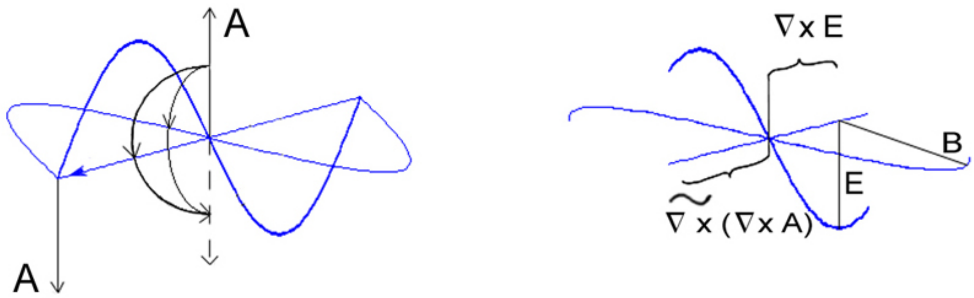

Figure 1: Schematic illustration of the phase of the events depicted by Eq. 3 (left side, A) and Faraday's law, Eq. 4, as estimated by an observer at a wave node (right side, B) A = vector potential, B = classical magnetic field, E = classical electric field, J_t = classical current density, transverse. Black arrows indicate paths taken by the vector potential, blue arrow the direction of propagation of the wave. Note that the apparent sinusoidal shape only serves to locate the local momentum observer (at an antinode) and the yonder, nonlocal observer (at a node)

Ampere-Maxwell's law is expressed in terms of the scalar and vector potentials,

$$\boldsymbol{\nabla} \times (\boldsymbol{\nabla} \times \boldsymbol{A}) = \boldsymbol{\mu_0 J} - \frac{\boldsymbol{1}}{\boldsymbol{c^2}}\boldsymbol{\nabla}\frac{\boldsymbol{\partial\phi}}{\boldsymbol{\partial t}} - \frac{\boldsymbol{1}}{\boldsymbol{c^2}}\frac{\boldsymbol{\partial^2 A}}{\boldsymbol{\partial^2 t}} \tag{2}$$

where, in the present theory, the first term describes a rotation of 180^o of the vector potential in the plane transverse to the momentum axis and the second and third terms add up to a transverse current term in the Coulomb gauge [26] having the same signature as displacement (cf. Table I) which is rewritten as $(J_t/\epsilon)c^{-2}$ with signature [1/~] [1/–]. The fourth term is rewritten using the new notation $1/\partial t = \widetilde{\nabla\times}$ which reflects the vectorial nature of time acting briefly, its being transverse to the momentum axis, and the fact that it causes the entity acted on to shift frames (back and forth between the local and the yonder frame). The time-vector product but not the scalar product may cause such a frame shift. Furthermore, in the case of electromagnetic radiation in vacuum where $c = 1$, $\nabla\times$ and $\widetilde{\nabla\times}$ have the same magnitude. Eq. 2 may then be rewritten as

$$\boldsymbol{\nabla} \times (\boldsymbol{\nabla} \times \boldsymbol{A}) + \widetilde{\boldsymbol{\nabla}\times}(\widetilde{\boldsymbol{\nabla}\times}\boldsymbol{A})\boldsymbol{c^{-2}} = \frac{\boldsymbol{J_t}}{\boldsymbol{\epsilon}}\boldsymbol{c^{-2}}. \tag{3}$$

where c^{-2} is a scaling factor. Ampere-Maxwell's law written in this form has a particular physical interpretation. Namely, the vector potential changes orientation by 180^o and does so by simultaneously moving in one plane perpendicular to the momentum axis and another plane that includes the momentum axis. For example, if the vector potential has its maximum value pointing up at a node of the wave then the first and second terms imply that it turns down at the next node of the wave, as illustrated in Fig. 1 A. It takes two paths (like in the path integral theory), one entirely in the yonder frame (1:st term), the other partly in the momentum frame (2:nd term), and the non-equivalence of these two paths gives rise to the 3:rd term. (In the classical treatment of electromagnetic radiation the 3:rd term is regarded as the source of the field.) Through the use here of two separate frames electromagnetic radiation becomes its own reference, its own aether so to speak, perhaps even a "new" aether [27]. Similar 'wave' equations have long been used in dispersion theory [28][1] [29].

The successful integration of Ampere-Maxwell's law into the present geometry with a plausible physical interpretation suggests that the following working rules should be adapted:

[1]Eq. 5 in the quotation

1. Operating twice with $\nabla\times$ or twice with $\widetilde{\nabla\times}$ is equivalent of the wave moving by 180^o or π.
2. Operating once with $\nabla\times$ or once with $\widetilde{\nabla\times}$ is equivalent of the wave moving by 90^o or $\pi/2$. The convention is adopted that the use of these operators right-handedly causes the wave to propagate leftwards (Fig. 1)
3. Entities having one-dimensional signatures are allowed.
4. An entity or equation term that has a mixed signature may represent a physical process.
5. Entities or terms that are composite by classical notation but one-dimensional or dimensionless by signature may represent an allowed physical unit (e.g. the use of J/ϵ in place of μJ or J).
6. Two- or multidimensional signatures of the same kind are ambivalent.

As an example of rule 2, if an observer were located at a wave node and were given the task to identify the electric field, E, as something that has a maximum value when the vector potential in his frame has its minimum value he would cast Faraday's law, $\nabla \times E = -\partial B/\partial t$ where $B = \nabla \times A$, as

$$\boldsymbol{\nabla \times E = -\widetilde{\nabla\times}(\nabla \times A)} \tag{4}$$

and make the judgement illustrated in Fig. 1B. Although the electric field concept is not suitable for vector operations in the present geometry, as a factor in various composite terms it may be. For example, the Lorentz force is suitable for dissecting the field into two perpendicular components as in Eq. 1 which helps in locating the quantum observer. It is known empirically that the quantum observer prefers the antinode of the wave where the world is more visible in terms of momenta than at the node [30] [31] [32] [33] [34] [35]. Rewriting the Lorentz force, $f = qE + c^{-1}v \times B$, as

$$\boldsymbol{f = q(-\nabla\Phi - \frac{\partial A}{\partial t}) + c^{-1}\frac{\partial x_v}{\partial t} \times \nabla \times A \Rightarrow \frac{f}{\partial x_v} = \frac{q}{\partial x_v}(-\nabla\Phi - \frac{\partial A}{\partial t}) + c^{-1}\frac{1}{\partial t} \times \nabla \times A}\,, \tag{5}$$

rearranging and simplifying to

$$\boldsymbol{\frac{f}{\partial x_v} + \frac{q}{\partial x_v}(\nabla\Phi + \frac{\partial A}{\partial t}) = \frac{1}{\partial t} \times \nabla \times A \Leftrightarrow \nabla_v f + \nabla_v q(\nabla\Phi + \frac{\partial A}{\partial t}) = c^{-1}\widetilde{\nabla\times}(\nabla \times A)} \tag{6}$$

yields a momentum factor (1:st term) and a polarization factor (2:nd composite term), the sum of which equals a displacement of the vector potential (3:rd term) a wavelength distance of $\lambda/4$ from the node to the antinode. The 3:rd term (right hand side of Eq. 6) yields the additional information that as the wave propagates for a distance of $\lambda/4$ the vector potential briefly enters the momentum frame through the action of the time component which then takes its place in parallel or antiparallel fashion in the yonder frame. Only this mechanism of action, which indicates that the yonder frame has internal structure (here with respect to the instant relative orientation of A and t), causes the wave to be visible in the form of classical momentum and/or classical polarization (left hand side of the equation). Hence, putting the notoriously classical Lorentz force into the present geometry in a flash chops it down to the quantum level. Although classical momentum and polarization may become visible at the antinode (left hand side) the frame signatures do not indicate that they are yet visible to the quantum observer. For this to be the case some kind of interaction with a matter component is needed, which is well described in the literature (e.g. references above).

Eq. 3 and 6 show that 1) electromagnetic radiation can be accommodated in the present geometry comprising a momentum frame and a yonder frame invisible to the quantum observer and 2) the radiation can be regarded as alternately identified by the two observers in their respective frames of observation. From the point of view of the present theory it is interesting that it is possible to regard the classical optical force as constituted by a longitudinal and a transverse component [30]. The notion of a local and a separate yonder frame of observation which alternately identify the object may facilitate the understanding of phenomena such as quantum walks [35] and matter waves [36] since matter has signature $\tilde{\ }$ and requires $\tilde{\ }\ \tilde{\ } \rightarrow \bar{\ }$ to be visible.

4 Arbitrary Waves and Matter

If one writes the de Broglie equation in geometrical units as

$$p\lambda = h \Rightarrow 2\ dx\ r = h \tag{7}$$

the momentum and wavelength on the left hand side define a unit length squared, the Planck length, which requires p and λ to be inversely proportional. In a Cartesian geometry the second equation above has the interpretation that an observer refers a radius of arbitrary length, r, to its inverse so as to match their product to the ubiquitous unit length $\sqrt{h}$. This possibly indicates why de Broglie regarded photons as Democritean atoms of light related to Bohr orbits of electrons [37]. The purpose here of making this comparison is to recall that in the present geometry,

$$\overline{q}\ \overline{\Delta q} = -1\ , \tag{8}$$

where $\overline{q}$ is the radius of the universe and the inversely proportional $\overline{\Delta q}$ is the apparent local cosmological expansion per unit time. The unit qubic length contains one baryon and one electron, which is regarded as a quantum of matter, and which is twice the observed value [8] [13]. Therefore, Eq. 7 and 8 are conceptually equivalent (with caution paid to the factor 2 in Eq. 7 and the peculiar geometry implied in Eq. 8), both bringing out the quantum nature of space. Comparison of the two equations above gives some further justification for regarding the mono-baryonic atom as the natural matter quantum of the universe, adding to the four distinct numerical arguments published earlier [8] [13].

De Broglie first showed that the world can be described with dual language, as matter and waves. The results presented here, by accommodating electromagnetic radiation, provide further evidence that the world *in essence has two tangible components*, one local frame of observation and a separate frame of observation, inaccessible to the quantum observer.

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