Exploring the Edge of the Universe In a Spacecraft Made of One Hydrogen Atom*

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Abstract

Using algebraic methods based on the Bohr atom, events are identified that take place at the absolute cosmological horizon where the apparent expansion rate equals the velocity of light. An infinitesimal excitation of the electron at the horizon equals the uncertainty of its location within the radius of the universe, $1.296 \times 10^{26} m$. As previously shown, this is the inverse of the apparent expansion rate factorized out of the Bohr ground state, $7.714 \times 10^{-27} m^{-1}$ whereby gross nonlinearities (acceleration and decelaration) are explained quantitatively as an effect of the geometry of the universe. Hence, the age of the universe is 13.7 billion years in this model. The excitation and absorption of photons by the hydrogen atom are put in a geometry comprising a momentum observer and another observer of tangential velocities. Hereby the electron oscillating in one dimension on average co-locates with the nucleus, which equates to magnetic charge enclosed by current at the horizon. The geometry allows the identification of physical processes separated from scaling factors in the applicable equations. For example, the interaction between matter and radiation can be identified. The plain theory also yields the energy density of the cosmic microwave background radiation at $3.382 \times 10^{-58} m^{-2}$ based on the energy of the oscillating unit length at the horizon and relevant scaling factors. The results show that the apparent cosmological expansion rate, the radius of the universe, its energy density of CMBR and even the universe's age can be regarded as constants of nature consistently with the geometry of the hydrogen atom. An advantage of the present methods in comparison with classical quantum mechanics is that they provide hints about the physical processes taking place during excitation/absorption rather than just enumerating the initial and final states. Furthermore, in comparison with relativity theory a preferred frame of observation is identified, that of the momentum observer who ignores the physics that lacks impact. This diminishes the prolixity of physical descriptions of phenomena of nature. Whereas the four-vector concept can not even explain why time proceeds in the rest frame the coincidence of time intervals perpendicular to momentum naturally identifies the context of every observation leaving for ever the observer at present time while ignoring any time axis.

Keywords: Bohr atom, hydrogen atom, Bohr-Dirac Quantum Universe, CMBR, cosmic microwave background radiation, signal transmission, signal transfer, excitation, absorption, magnetic monopole, hydrogen ground state, Hubble constant

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1 Introduction

This work is intended to explore quantitative implications of the 'Bohr-Dirac Quantum Universe' using algebraic methods. This universe arises in a particular geometry comprising a momentum frame and a space-like separated transverse frame of observation [1], [2] whereby the apparent cosmological expansion rate is factorized out of the Bohr ground state, which is then recast into a form reminiscent of a Dirac string [3]. The classical Bohr theory [4] as can be found in textbooks of the early 20:th century (e.g. ref [5]) is recalled in eq. 1 - 18 below with the present objectives in mind followed by its implementation in the present author's theory. In the scientific literature one can often read that since the Bohr theory could not explain fine structure, spin, etc. it was wrong, and it was therefore superceded by theories which could explain these phenomena. However, it may not be necessary to invoke all the subtleties of electron dynamics in order to make the point that the geometry of the ground state of the hydrogen atom represents the most stable state of matter and therefore reflects the preferred geometry of the entire universe.

2 Background and Theory

In the Bohr theory of the hydrogen atom the negatively charged electron circulates in the $k : th$ orbit ($k = 1, 2, 3...$) around the positively charged nucleus, attracted by the Coulomb force, which equals the centrifugal force [1],

$$\frac{e^2}{{a_k}^2}\frac{1}{4\pi\epsilon_0} = M_e\frac{{v_k}^2}{a_k} \tag{1}$$

The orbital angular momentum of the electron is a multiple of Planck's constant,

$$M_e v_k a_k = k\hbar \Rightarrow v_k = \frac{k\hbar}{M_e a_k} \ . \tag{2}$$

Eq 1 and 2 allow the elementary charge, e, to be expressed as

$$\frac{e^2}{4\pi\epsilon_0} = v_k\hbar k \Rightarrow \frac{e^2}{4\pi\epsilon_0\hbar} = v_k k \tag{3}$$

or

$$\frac{e^2}{4\pi\epsilon_0} = \frac{\hbar^2 k^2}{M_e a_k} \Rightarrow \frac{e^2}{4\pi\epsilon_0\hbar^2} = \frac{k^2}{M_e a_k} \tag{4}$$

and are solved for the radius of the orbiting electron and its velocity,

$$a_k = \frac{\hbar^2 k^2 4\pi\epsilon_0}{M_e e^2} = a_0 k^2 = \frac{1}{\alpha}\frac{\hbar k^2}{M_e c} = constant \times {M_e}^{-1} \times k^2; \tag{5}$$

$$v_k = \frac{e^2}{\hbar k}\frac{1}{4\pi\epsilon_0} = \alpha\frac{c}{k} = constant \times k^{-1} \tag{6}$$

[1] Notations: a_k = radius of the electron orbit in the k:th shell; k = the number of the orbit from nearest to farthest away from the nucleus; a_0 = radius of the electron orbit in the ground state ($k = 1$); h = Planck's constant; $\hbar = h/2\pi$); ϵ_0 = the permittivity of vacuum; M_e = rest mass of the electron; e = charge of the electron (the elementary charge); α = fine structure constant, cf. eq. 23; v_k = velocity of the electron in the k :th orbit; c = velocity of light in vacuum; m = meter; sec = SI unit of time; s = unit of time geometrized in terms of m; H = Hubble's constant (the apparent cosmological expansion rate) in units m/ms in the local frame and current epoch

The number of turns per second of the orbiting electron, n_k, is

$$n_k = \frac{v_k}{2\pi a_k} = \frac{M_e e^4}{2\pi k^3 \hbar^3 (4\pi\epsilon_0)^2} = \frac{M_e c^2 \alpha^2}{h k^3} = constant \times M_e \times k^{-3}\ sec^{-1} \tag{7}$$

and the period τ_k is

$$\tau_k = \frac{1}{n_k} = \frac{2\pi k^3 \hbar^3 (4\pi\epsilon_0)^2}{m e^4} = constant \times M_e{}^{-1} \times k^3 = constant \times k^3 \tag{8}$$

$$= 1.5215 \times 10^{-16} sec \times k^3 = 5.075 \times 10^{-25} \times k^3\ s \tag{9}$$

In the deBroglie theory of matter waves (ref. [6]) every particle of mass M and velocity v is associated with a wavelength λ related through (cf. eq. 2)

$$Mv\lambda = h \tag{10}$$

where $p = Mv$ is the momentum of the particle. The velocity of the orbiting electron can then be expressed as $v_e = \lambda_e/\tau_e$ where τ_e is the period of the electron's matter wave,

$$\tau_e = \frac{h}{M_e v_e{}^2} \tag{11}$$

wherein $v_e = v_k$ is substituted using eq. 6:

$$\tau_e = 2\pi \frac{\hbar^3 k^2 (4\pi\epsilon_0)^2}{M_e e^4}. \tag{12}$$

a_k from eq. 5 divided by eq. 12 is a constant of dimension rate, considering eq. 5:

$$\frac{a_k}{\tau_e} = \frac{e^2}{4\pi\epsilon_0 h} = \frac{k v_k}{2\pi} \tag{13}$$

Further dividing eq. 8 by eq. 12,

$$\frac{\tau_k}{\tau_e} = k \tag{14}$$

shows that the main quantum number can be regarded as a ratio of time scales, a dimensionless measure of time. k is the time scale 'measured' by the orbiting electron, the number of internal clock cycles it takes to explore how much space it has available. The classical view is that the electron forms a standing wave while in orbit, the number of periods of its own matter wave must break even with reference to the period of the circular orbit. This provides for an intuitive understanding of the initial and end states of the hydrogen atom emitting or absorbing a photon. The actual process of emission or absorption is however often considered not to be possible to understand based on classical physical concepts like the above described resonance.

What happens actually during signal-matter interaction? Transitions between states of different main quantum numbers k or l, (enumerating the orbits) are accompanied by emission or absorption of light quanta of frequency ν_k

$$\nu_{k,l} = \frac{k n_k - l n_l}{2};\ k n_k = \frac{1}{2}\frac{k v_k}{2\pi a_k} = \frac{M_e c^2 \alpha^2}{2 h k^2} \tag{15}$$

where $k > l$ for emission, and energy

$$E_{k,l} = h\nu_{k,l} = h\frac{k n_k - l n_l}{2};\ h k n_k = \frac{1}{2}\frac{h k v_k}{2\pi a_k} = \frac{M_e c^2 \alpha^2}{2k^2} \tag{16}$$

The operator formalism in wave mechanics builds on these equations. The operator takes the system from the initial to the final state only and is designed to ignore the actual physical mechanism(s) of energy transfer between matter and radiation, not quite unjustified since matter also behaves like a wave at these scales.

Eq. 16 can be derived since the energy of radiation (the signal) equals half of the potential energy E_{pot} that the electron looses when settling from infinity into any orbit and the other half goes into its kinetic energy, E_{kin}. Its kinetic energy, $M_e {v_e}^2/2$ is from eq. 1: $E_{kin} = e^2/2a_k$ and its potential (Coulomb) energy is $E_{pot} = -e^2/a_k$ The latter is maximal and equal to $E_{pot} = 0$ at infinite separation, $a_k \rightarrow \infty$, where also $E_{kin} \rightarrow 0$. Adding E_{kin} and E_{pot} provides the electron's energy available for exchange with radiation, E_{exch}, at infinity and/or locally,

$$E_{exch} = -\frac{1}{2}\frac{M_e e^4}{\hbar^2}\frac{1}{(4\pi\epsilon_0)^2}\frac{1}{k^2} = -\frac{M_e c^2 \alpha^2}{2k^2} \tag{17}$$

such that from two distinct orbits k and l, the radiation energy associated with a change of orbits is

$$h\nu = \frac{M_e c^2 \alpha^2}{2}\Big(\frac{1}{k^2} - \frac{1}{l^2}\Big) \Rightarrow \nu = \frac{1}{2}\frac{M_e e^4}{2\pi\hbar^3}\frac{1}{(4\pi\epsilon_0)^2}\Big(\frac{1}{k^2} - \frac{1}{l^2}\Big) \tag{18}$$

where the second equation yields eq. 15 if one considers eq. 7. From a classical point of view the atomic electron acquires velocity & kinetic energy when emitting (cf. eq. 6). In other words, it accelerates. It is noteworthy that the electron's acceleration takes place perpendicular to the momentum of the photon with which it interacts. In systems where the electron is not tied to the hydrogen atom its centrifugal acceleration is nevertheless associated with radiation like in the case of synchrotron radiation or electrons accelerated into gravitational fields of astrophysical objects. It therefore seems that acceleration of electrons is fundamentally linked to emission of radiation. Since a higher value of the quantum number k is associated with a longer radius and a larger time scale (cf. eq. 5, 14) the hydrogen atom has a geometry which is similar to the universe. Furthermore, at some fixed point close to infinity it has almost no kinetic energy at all and consequently vanishingly small momentum. Like all other matter the electron will position itself with high precision at the center of the universe. Nevertheless, its position at origo is uncertain by as much as the radius of the entire universe since the latter does not have any absolute coordinates. Based on the Heisenberg uncertainty relation of momentum p and position x,

$$\Delta p \Delta x = m\Delta v \ \Delta x = \frac{\hbar}{2}, \tag{19}$$

the electron's velocity in the context of the entire universe of radius r_u can be calculated [2]:

$$M_e \ \Delta v_{e,ru} \ \Delta r_u = 6.764 \times 10^{-58} \ \Delta v_{e,ru} \ 1.2296 \times 10^{26} = \frac{2.612 \times 10^{-70}}{2} = \frac{\hbar}{2} \tag{20}$$

$$\Rightarrow \Delta v_{e,ru} = 1.489 \times 10^{-39}. \tag{21}$$

This is a rather small velocity to observe even for the electron or the proton while they interact. However, in the case the electron accelerates during its period characteristic of the ground state, τ_1, (cf. eq. 9) from a state where $v_e = 0$ to the orbit that defines the radius of the universe according to eq. 20, it is capable of defining a length close to its own radius,

$$\frac{v_{e,ru}}{\tau_1} = 2.934 \times 10^{-15} m/s^2, \tag{22}$$

[2] The numerical value of the radius of the universe below, r_u, is obtained by interpreting the ground state of the Bohr atom as an instance of a Dirac string, [3];$4(ec/2\alpha)\ {r_u}^{-1} = \sqrt{\hbar}\ 2\pi\ Ampere\ s^{-1}$

which is 1.04× the classical electron radius $r_e = 2.818 \times 10^{-15} = \alpha^2 a_0$. In contrast to the ambiguous velocity obtained from eq. 20 this is a physically relevant distance based on a plausible physical process (subject to some conditions discussed below). It tells that the huge indeterminacy of the electron's position in the universe is balanced almost precisely by its own spatial extension while it undergoes a remote transition from a rest frame at the cosmological horizon. In this interpretation the indeterminacy expressed by eq. 20 represents an end state whereby the emergence of the entire universe from an absolute rest frame is implicit. This conclusion is based on selecting a full period τ_1 as the 'physical' time during which the electron interacts. Choosing $\tau_1/2$ as its time scale defines the diameter of the universe while choosing $2\tau_1$ defines half the radius of the universe, a distance approximately where modern astrometrics has discovered the onset of an acceleration of the apparent cosmological expansion rate. These interesting findings rely on the assumptions that 1) the period of the electron's orbit in the ground state has some physical relevance also at the remote locality and 2) vacuum polarization or some similar process is capable of adjusting by the factor 1.04 the approximate numerical results of eq. 22 into an exact process. For example, 1a) the remote and the local may be linked quantitatively similar to the Bohr ground state being rewritten as a string-like universe extending from origo to an equal unit current at the cosmological horizon (ref. [3]) or 1b) the electron may have some intrinsic property that manifests itself as an effect of the period of the ground state orbit irrespective of any proximity to a proton. It is also noteworthy that in a geometry where momentum and tangential velocity are space-like separated [1] [2] 1c) the remote location can not be seen from the laboratory (=momentum) frame, it is in this sense non-local, and may thus be regarded as part of the laboratory frame. Eq. 22 expresses a (continuous or discontinuous) translation on the momentum axis and another one at right angles to this axis related to the inverse of time squared, which will be useful for evaluating the 'physicality' of the equation. It is likely that the proton and the electron were created in proximity rather than at the huge separation of r_u. A complete ionization of the hydrogen atom with the electron at infinite distance from the proton is thus probably an unphysical scenario for the early universe. The universe is of course the ultimate quantum phenomenon, it either exists or does not exist, which implies that the processes at its absolute edge deduced from eq. 20 have some particular significance.

The factor 1.04 may possibly be linked to the fine structure constant, which is ubiquitously involved in any electron dynamics. The composition of the fine structure constant that bears on its 'running' (increase of its numerical value) at small distances because of vacuum effects (polarization etc.) has been clarified in ref [7]. It increases because of the Coulomb force, decreases because of magnetic forces and is also influenced by the constant of the Casimir force when the distance of interaction decreases. The fine structure constant, α, originally defined as $\alpha = v_1/c$, where v_1 is the electron's velocity in the ground state orbit, can be expressed as [3]

$$\alpha = \frac{e^2}{4\pi\epsilon_0\hbar c} = \frac{1}{4}\frac{e}{\phi_0}\sqrt{\frac{\mu_0}{\epsilon_0}} = \frac{1}{4\sqrt{2}}\sqrt{\frac{\Phi_e}{\Phi_\phi}} \tag{23}$$

where the constant of Casimir force[4], $\hbar c = (\sqrt{2}/\pi\sqrt{\Phi_e\Phi_\phi})$, the velocity of light, $c = 1/\sqrt{\epsilon_0\mu_0}$ and $\hbar = e\phi_0/\pi$. The constant may increase at smaller distances provided any of the other constants of nature above changes values also. The hypothesis that the factor 1.04 obtained above represents an involvement of the fine structure constant may be evaluated by applying the geometry of refs. [1] and [2] to the Bohr atom and the universe combined.

If the neutrinos were the universe's soul then the distinction of a well-defined recipient frame

[3]Notations: ϵ_0 = permittivity of free space in Farads/meter: ν_0 = permeability of free space: ϕ_0 = quantum of magnetic flux due to the spin of the electron (quantum of spin angular momentum per one unit charge, a static quantized magnetic flux loop); $\Phi_e = e^2/\epsilon_0$; $\Phi_\phi = {\phi_0}^2/\mu_0$

[4]$F_C/A = \hbar c\pi^2/240a^4$, A=area, a=distance between parallel plates

involved in all observations would be its consciousness. Such a frame of observation must inherently select physical entities that constitute an interaction with the recipient observer (like momentum) and ignore other descriptions (like velocity) as has already been evaluated in ref. [8]. Let the barred frame of the coordinates

$$(q_0, t_0) = \Big(\frac{\sqrt{1-v^2/c^2}}{v}\frac{m^2}{s},\ 0\Big);\ \ (\overline{q_0}, \overline{t_0}) = \Big(\frac{1}{v}\frac{m^2}{s},\ -s\Big) \tag{24}$$

related through a Lorentz transformation, represent such a frame of observation of all that is 'conscious' to the barred observer and let the observation be evident one unit of time later:

$$(q_r, t_r) = \Big(\frac{\sqrt{1-v^2/c^2}}{v}\frac{m^2}{s},\ s\sqrt{1-\frac{v^2}{c^2}}\Big);\ \ (\overline{q_r}, \overline{t_r}) = \Big(\frac{1}{v}\frac{m^2}{s} - vs,\ 0\Big)\ . \tag{25}$$

Then the latter coordinate inherently contains a line increment, $\Delta\overline{q} = \overline{\Delta q}$ (an extension of space in one dimension),

$$(\overline{q_r}, \overline{t_r}) = (\overline{q_0} + \Delta\overline{q}, 0)\ , \tag{26}$$

which represents momentum and is related to the velocity v through

$$\overline{\Delta q} \equiv -vs\ . \tag{27}$$

It is known that the velocity v is tangential to the line increment [1] [2]. When applied in cosmology the line increment $\overline{\Delta q}$ per unit length per unit time represents the Hubble expansion rate, H [3] [9] [10] and

$$\overline{q} = \frac{-m^2}{\overline{\Delta q}} \Rightarrow H = \frac{1}{r_u}. \tag{28}$$

Consistently with the geometry implicit in eq. 27 where a line increment on the left side equals a tangential velocity on the right side, using the numerical value of eq. 21:

$$H = 2\frac{\Delta v_{e,ru}}{a_0\alpha} \Rightarrow\ \ 7.714\times10^{-27} = 2\ \frac{1.489\times10^{-39}}{5.292\times10^{-11}\times0.007297}. \tag{29}$$

Hence, the fine structure constant is clearly involved in the edge velocity $\Delta v_{e,ru}$ in such a manner that had the constant had a higher numerical value the fit in eq. 22 would be better. The edge velocity found by arbitrarily applying the uncertainty relations to the entire radius of the universe does not fit into any presently known context in physics but an empirical context can be found while regarding in a general sense the left side of eq. 29 as a vacuum phenomenon and the right side as some manifestation of the electron. Then it is relevant (cf. [9] [11]) that the measured energy density of the cosmic microwave background radiation (abbr. 'CMBR', for a modern estimate, ref. [12], $2.7\times10^{-7}MeV/cm^{-3} = 3.57\times10^{-58}\ m^{-2}$) is approximately half of the energy of the electron per unit length, $6.764\times10^{-58}\ m^{-2}$, [5]. The empirical ratio is thus close to 1:2 whereas the ratio deduced from eq. 29 is 2:1. Arguments can easily be found for dividing the right side of eq. 29 by 4 to make it compliant (up to the factor α^{-1}) with the empirical equations 15 and 16. For example, as discussed above in connection with eq. 22, the relevant uncertainty length might be half of r_u, which would make the weighting factor 2 superfluous. Another factor 1/2 might be accounted for if, fundamentally like in the Bohr theory proper, only half of the energy goes into radiation. Furthermore, if positrons and electrons

[5] The empirical evidence of one primordial particle per unit length in the universe, based on the inherent geometry in eq. 25 and 27: $\overline{\Delta q}\ \overline{q} = -m^2, \overline{q} = r_u$ has been summarized in ref [13]

are created in pairs at the edge of the universe and the only the former transform into microwave radiation the effective energy density expressed by the right side of eq. 29 would be $2v_{e,ru}$ rather than $v_{e,ru}$

Before making another attempt to obtain the absolute value of the energy density of the CMBR the same geometry will be applied to signal transfer (emission-absorption). For this purpose the right side of the above equation is divided by 4 to make it compliant with eq. 15. The uncertainty of $\Delta v_{e,ru}$ is regarded as an instance of v_k and the factors are then substituted using eqs. 6, 5 and 23, with eq. 4 for M_e;

$$2\Delta v_{e,ru}\frac{1}{a_0\alpha}\Big/4 = \frac{1}{2}\ \frac{e^2}{\hbar k}\ \frac{M_e e^2}{\hbar^2 1^2}\ \frac{\hbar c}{e^2}\ \frac{1}{4\pi\epsilon_0} = \frac{1}{2}\ \frac{c\ \ k}{a_k}. \tag{30}$$

The left side of eq. 29 is then substituted using (cf. [3])

$$\overline{\Delta q} = H = \frac{\sqrt{\hbar}}{2}\pi\ \frac{2\alpha}{ec}Ampere\ c = \frac{\sqrt{\hbar}\pi Ampere}{2\overline{Q}}\ c \tag{31}$$

where $\overline{Q}$ is the unit magnetic charge (cf. [16]). Equating eq. 31 and 30 followed by rearranging yields

$$\Big[\frac{a_k}{k}\Big]\sqrt{\hbar} = \Big[\overline{Q}\Big]\frac{1}{\pi Ampere}. \tag{32}$$

This result conforms to the geometry implicit in eq. 27 with a momentum observer on the left side (the electron) and a tangential velocity (the current yielding magnetic charge) on the right side. Since the electron can not measure any distance longer than its own diameter except through a velocity, the factor a_k has been divided by the dimensionless measure of time k as discussed in connection with eq. 14. As has already been pointed out [14] [15] a current at any distance from origo encloses the same magnetic charge so the right side of the equation may as well represent the edge of the universe. Since the two observers are space-like separated in the present geometry and occupy frames of observation at right angles to each other they are also non-local to each other. The entities that have physical meaning, corresponding to physical processes in this geometry have been put into brackets followed by scaling factors. Since the period of any event presents at least exactly one opportunity for a given physical process one may factorize k (cf. eq. 14) with preserved physicality to obtain

$$\Big[\frac{4a_k}{\tau_k}\Big]\sqrt{\hbar} = 4\Big[\overline{Q}\ \frac{1}{\tau_{e,k}}\Big]\ \frac{1}{\pi Ampere}. \tag{33}$$

Here, the rate of fluctuation of the atomic radius seen by the momentum observer (the electron, that is) corresponds, tentatively, to the frequency by which the latter communicates with the electronic matter wave *via* a magnetic string with possibility of momentum transfer.

The classical description of eqs. 15 - 18 identify the initial and end states of emission/absorption without any hint at the actual processes taking place leaving a large number of combinations of states k and l that the electron must be able to evaluate before making a quantum jump. In contrast, eq. 32 and 33 indicate an axis of momentum transfer (possibly in terms of parallel or antiparallel magnetic moment) whereby the electron's average position coincides with that of the nucleus, enabling it to engage also the nucleus in signal processing. There is only one reference state (the magnetic charge) offering each state k and l a simplified means of information exchange. Furthermore, the magnetic charge is viewed as being enclosed by a tangential current as implemented in the spherical electron shell, which provides an intuitive understanding of signal processing in terms of perturbations of this electron shell being transformed into the momentum frame. In conclusion, putting the signal transfer into the geometry of eq. 24 - 27 identifies the actual physical processes taking place rather than just the initial and end states. These processes constitute a line increment in the momentum frame and a tangential velocity in the non-local frame. Once the factors that carry the 'physicality' of the process have been identified the other ones can be analyzed in terms of weighting factors. Using this method one can proceed from eq. 33 by factorizing the magnetic charge with the help of the definition of α (eq. 23), then rearranging:

$$\left(\left[\frac{4a_k}{\tau_k}\right] = \left[c^2\frac{1}{\tau_{e,k}}\right]\frac{2\sqrt{\hbar}}{e}\ \frac{4\pi\epsilon_0}{\pi Ampere} = \left[c^2\frac{1}{\tau_{e,k}}\right]2\sqrt{\hbar}\ \frac{s}{\pi}\frac{4\pi\epsilon_0}{e^2} = \left[c^2\right]\sqrt{\hbar}\left[\frac{1}{\tau_{e,k}}\right]\frac{2}{\pi}\ \frac{4\pi\epsilon_0\ s}{e^2}\right)(\times\sqrt{\hbar}) \tag{34}$$

where multiplication by $(\times\sqrt{\hbar})$ makes the frame signatures, cf. [8], of each side, $^{-\,-}/\ \sim$, that of energy. The tangential velocity c has a special significance in this geometry, it corresponds to the line increment $\Sigma\overline{\Delta q}/s = 1$, which is only seen at the outermost edge of the universe where each unit length of r_u has added its contribution to $H = \overline{\Delta q}$ until the cosmological redshift is infinite [6] [9] [13]. At such remote distances 3-dimensional space collapses into 2 dimensions in which electromagnetic radiation is embedded [17] [18]. In classical electromagnetic theory the factor c^2 above may be interpreted as velocity contributions from two perpendicular orientations harboring two components of wave propagation such that the factor in brackets to the right above is capable of representing an interaction between matter and electromagnetic radiation. Since time is perpendicular to the momentum frame here, the present geometry restricts the numbers of 'physical' representations of electromagnetic radiation to those based on the vector potential in place of the electric field [8]. The vector potential reverses its direction periodically by following two perpendicular paths, (anti)parallel and perpendicular to the momentum axis. The path that is parallel (antiparallel) to the momentum frame offers a means of interaction between matter and radiation in this geometry, likely *via* induction currents.

These results provide a background for estimating from plain theory the energy density of the CMBR which has been measured experimentally to $2.7 \times 10^{-7} MeV/cm^{-3} = 3.57 \times 10^{-58}\ m^{-2}$ [12]. Eq. 29 indicates that the apparent cosmological expansion rate corresponds to an oscillating tangential velocity of a unit charge at the horizon, which would be capable of generating radiation. Furthermore, the expansion rate increases linearly until it attains the value $1s^{-1}$ at the horizon. This corresponds to multiplying eq. 29 by the factor $r_u/a_0\alpha$ where the denominator is the same scaling factor per unit length that was used to make sense to the equation originally. Since half of the energy of the tangential velocity component has already been used to generate the vacuum instability contained in the apparent expansion rate (cf. eq. 29) only half of it remains. Therefore, using that the energy, $E = h\nu$, of the circulating unit charge would be linearized into one dimension $E/2\pi = \hbar\nu$

$$U(CMBR) \times m^3 = \hbar\frac{r_u H}{2a_0\alpha} = \hbar\frac{r_u \Delta v_{e,ru}}{(a_0\alpha)^2};\qquad \frac{2.612 \times 10^{-70}}{2 \times 5.912 \times 10^{-11} \times 0.07297} = 3.382 \times 10^{-58}, \tag{35}$$

which is quite close to the observed numerical value, 3.57×10^{-58}. The theoretical construct used above shows that the apparent cosmological expansion and the CMBR are two aspects of the same thing, inherent in the same geometry, that of eq. 24 - 27 [1] [2]. Furthermore, the polarization of the CMBR per unit (square) length due to the tangential velocity of the charge is evident. The approach using the total energy $h\nu$ is more straightforward and involves fewer speculative elements than that based on Raileigh-Jeans' law which was pursued previously. Nevertheless the bearing idea is the same, namely that the oscillating unit length at the horizon is at the heart of these phenomena. Eq. 35 yields a plausible value of the total energy density of the CMBR at 2.725 ^oK [7] but does not provide its statistical distribution. For this purpose one may return to the question of the 'consciousness' of the universe that is manifest in a preferred momentum frame seeing the interactive events and ignoring

[6] the measured apparent nonlinearity in the redshift (the so called 'acceleration' of the universe) is attributed to the geometry of the universe [13]

[7] the apparently hotter temperatures seen by remote matter is interpreted in terms of time dilatations in the present cosmological model

the physics that remains out of touch.

The frequency distribution of thermal radiation,

$$U(\nu)d\nu^{-1} = \frac{h\nu^3}{c^3\ exp(1 - \frac{h\nu}{kT})} \tag{36}$$

may be obtained by equating factors that by establishing the field, contribute to absorption,

$$U(\nu)\ c^3\ \nu^{-2}\Big(1 - exp(\frac{-h\nu}{kT})\Big), \tag{37}$$

with those that contribute to the instability of the excited state in the matter, [20] [21]

$$h\nu\ exp(\frac{-h\nu}{kT}). \tag{38}$$

Hence, by analogy with the left and right sides of eqs. 33 and 34,

$$\Big[\frac{h\nu}{\sqrt{\hbar}}\Big]\frac{1}{U(\nu)\ c^3/\sqrt{h}}\ exp(\frac{-h\nu}{kT}) = \Big[\tau^2\Big]\Big(1 - exp(\frac{-h\nu}{kT})\Big), \tag{39}$$

the momentum of radiation emitted from the solid state per unit energy in the field (left side) is proportional to an event involved in radiation that occurs once per cycle in two perpendicular dimensions of the non-local frame (right side). This interpretation of course takes the black cavity radiation out of its classical context, a step that was taken long ago anyway, with its statistical interpretation.

The same mathematical form also yields quantitative interdisciplinary results in gene kinetics and economics [21]. It can also be applied to black hole radiation and cognitive processes [21]. Thereby it provides an argument when evaluating if the universe is equipped with such faculties like 'consciousness'.

The squared period above is also useful for quantitative determination of the masses of the W and Z bosons based on the vacuum instability represented by the apparent cosmological expansion rate [22].

3 Discussion

The present results show that processes take place at the cosmological horizon that are amenable to analysis within the framework of the Bohr atom. At such remote distances oscillations at the speed of light take place, brought to the attention by the present numerical results. Therefore, the absolute horizon as defined here is a relativistic event horizon similarly to black holes that are capable of generating radiation and particles [23]. But any observer at any distance from the horizon traveling at any velocity measures the velocity of light to the same numerical value, which means that the velocity *per se* is disconnected from velocities in the material world. The traditional way of dealing with this problem is the arithmetic 'elementary school approach' - guessing that matter and radiation should fit into the same space-time construct, notably that stretched and compressed and bent by relativity theory applied to the Cartesian coordinate system. However, an observer of one-dimensional momentum as defined here is indifferent to events taking place in a perpendicular frame of observation. There is no distance between such perpendicular frames to the effect that events in the transverse frame, no matter how far away, can be thought to permeate invisibly the momentum frame. Consistently with this view electromagnetic radiation is present in the local frame even though the space-time symmetry of massless particles requires a group contraction to long radii [17] [18]. The permeation of the local frame by the visible CMBR of distant origin is also relevant. The outermost edge of the universe is thus represented locally by massless particles, like photons. But a relativistic event horizon may also generate massive particles *via* matter-antimatter fluctuations [23] or energy-time uncertainties. Since matter is non-local as proven by its wave properties and also appears perpendicular to the momentum frame in the present geometry [8] the possibility then arises that the local matter also is a representation of such ongoing processes.

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