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.*

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Abstract

The thermal distribution of electromagnetic radiation and the velocity distribution of stars in spiral galaxies are examined by reference to a quasi-topological geometrical framework constituted by a one-dimensional momentum frame and a non-local frame devoid of spatial measurements. The observers in the local and non-local frames are space-like separated and connected by, also entangled in, Lorentz-transformations. The general geometrical properties of this mathematical construct are summarized. Besides its common relativistic interpretation the geometry also allows the Lorentz factor to be interpreted by number theory to connect the signal source and sink in the space-like separated frame of observation. The quasi-topological quantitative approach yields the result that thermal radiation and star velocity distribution are equivalent in every aspect. A heavy 'field' interacting with matter in galaxies corresponds to the electromagnetic field of thermal radiation. This field, a 'Hubble field', can be identified quantitatively as having its origin in the apparent cosmological expansion in the current epoch.

1 Introduction

It is important to have a good understanding of the Planck distribution [1], which has a long history in physics. Before its statistical interpretation was established by Bose in 1924 [2] several successful attempts were made to interpret the distribution in terms of some physical properties or processes [3] [4] [5] [6] [7]. The thermal distribution of radiation is now regarded as an unquestionable founding brick of physics and rarely revisited, most recently in connection with black holes [8]. However, in recent years there has been a growing interest in the topological aspects of physical processes. The contemporary understanding is that physical processes are not only represented quantitatively-numerically by "equal-to" equations but a richer and more precise description can be obtained if these equations can be put into some topology and/or geometrical framework. The favored geometrical framework in contemporary physics is special and general relativity theory wherein the Galileean reference frame is

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a special case. These naturally embed *some* important features of electromagnetic radiation but do not in any way deepen our understanding of thermal radiation. In the present work, an alternative geometrical framework is evaluated, which specifically addresses the local momentum transfer in one dimension and the perpendicular non-local wave front that characterize thermal radiation. Both the source-sink aspects and the non-locality of the wave-front are absent from Maxwell's theory of radiation which also has been criticized for a vague understanding of the so-called displacement current and for gauge ambiguity.

The present approach to thermal radiation consists in restricting the momentum-frame to one spatial dimension, which makes all other directions non-local with respect to that one dimension and further by making measurements of spatial coordinates impossible to perform in the non-local frame, by definition. The details of this mathematical construct [9] have been published before e.g. [10] [11] and are also for the reader's convenience described in Appendix I below. In comparison with relativity theory the absence of measurable spatial coordinates in the non-local frame excludes this geometry from the general Poincare group and the discontinuity implicit in the non-locality makes a topological interpretation difficult. However, the herein investigated geometry constituted by a local 1-D observer by Lorentz-transformations entangled with a non-local observer naturally applies to many different physical processes in the very spirit of topology (some examples are described in [12] and [11]). In the present paper the implications of this quasi-topological geometrical construct for a more profound understanding of the Planck distribution will be examined.

2 Brief Characterization of the Herein Applied Geometrical Framework

For an observer confined to one single dimension, non-locality in any other dimension is the only possible world picture. It is well known that the atom absorbs and emits energy in quantized amounts that must be pointed, straight or axially, exclusively in one direction at the time of each energy transfer, each observation of its surroundings. In the present theory, one observer, confined to a single spatial dimension interacts *via* Lorentz transformations with another space-like separated observer who measures time only. This geometrical construct (Appendix I) has the following inherent peculiarities distinguishing it from the Cartesian coordinate system -derived topological frameworks:

1. Each unit length comes with a line increment.
2. The line increment is the inverse of a length interpretable as a radius along the direction of observation. Hence,

$$\overline{q}\ \overline{\Delta q} = -m^2 \tag{1}$$

3. Time is perpendicular to the axis of observation of momentum.
4. The line increment per unit time equals a perpendicular velocity:

$$\frac{\overline{\Delta q}}{s} = v \tag{2}$$

which will be used as a basis for the present work. This implies that factors in the local frame are numerically equal to factors in the non-local frame. The local and the non-local factors can be identified as such by their known physical roles and by their 'frame signatures' since all physical entities can be assigned such frame signatures [13] [14]. Furthermore,
5. the time dilatation of special relativity (SR) is preserved.
6. There is a relativistic length contraction confined to the non-local dimension, which is space-like

separated from the local observer. In contrast, SR has its relativistic length contraction along the line of sight in the local frame.

7. There is a relativistic horizon obtained by adding line increments linearly in the local-momentum frame of observation under the assumption that every unit length along the momentum-line of sight preserves the same geometry:

$$\sum_{n=\overline{\Delta q}}^{1} \overline{\Delta q} = 1 \quad \equiv \quad \sum_{n=1}^{\overline{q}} = \overline{q} \tag{3}$$

3 Results and Discussion

The thermal distribution of electromagnetic radiation derived originally by M. Planck in the form [2]

$$U(\nu)\ d\nu^{-1} = \frac{8\pi h\nu^3}{c^3}\ \frac{1}{exp(\frac{h\nu}{kT}) - 1} \tag{4}$$

where U is the intensity of the radiation per frequency ν increment, $d\nu$, h is the non-reduced Planck's constant, c is the velocity of light, k is Boltzmann's constant and T the absolute temperature, is rearranged into

$$h\nu\ exp(\frac{-h\nu}{kT}) = \frac{c^3}{8\pi}\ U(\nu)d\nu^{-1}\ \tau^2\ \Big(1 - exp(\frac{-h\nu}{kT})\Big) \tag{5}$$

where the left side has terms that are local in the momentum-carrying dimension and the right side contain terms that are perpendicular to the line of sight and hence non-local. Collecting local terms on the left side and non-local ones on the right side will subsequently be done by author's convention. In the present geometry this arrangement of terms derives from the equality 2 above. The left side contains the momentum transfer to and from the matter, $h\nu$, and the exponential term which is interpreted classically as a probability that the excited state of the matter decays. The exponential term was extensively characterized in the early 20:th century, e.g. [1] [2] [3] [4] and is known as the Maxwell distribution [4]. The right side contains the complementary probability that the electromagnetic field transfers energy to the matter. Furthermore, the right side contains the field intensity per frequency component, which is known to result from a squared probability amplitude, and the oscillation period τ of the radiation squared. In accordance with the present geometrical framework and with the well-established directions of the electric and magnetic fields of electromagnetic radiation these components are perpendicular to the momentum axis. Hence, the geometry embeds in a natural way thermal radiation. It is noteworthy that in the present case the field intensity appears as a function variable rather than as a function value like in the well-established approaches to Planck's equation. Letting the amplitude work jointly with the squared oscillation period to establish the radiation field like in eq. 5 is consistent with many known exceptions from the Einstein-Bohr energy level rules [15] [16]. The form and interpretation of eq 5 given here applies at equilibrium when any forced absorption of radiation is immediately emitted so that stimulated emission can be neglected or likewise, the radiation intensity is low in comparison with spontaneous emission. An analysis of stimulated emission can be found in [5].

Since any additional dimension is non-local with respect to the dimension that carries momentum the geometry naturally accommodates the non-local character of the wave-front as well. In the just described picture of emission-absorption, the atom redefines its one-dimensional momentum axis upon every consecutive quantum transfer whereas the field components are perpendicular and hence non-local.

These preliminary results indicate that the proposed geometrical framework is well suited for further explorative theory in the field of radiation-matter interactions. Such an investigation will now be undertaken.

First, since classical derivations of black cavity radiation contain the surface angle and the polarization, the factor 8π is removed from eq. 5. This makes the equation better adapted for the above described one-dimensional geometry. Subsequently, the Planck constant is factorized as previously shown [17] [18] [11], now in the non-reduced form, as

$$h = (\overline{\Delta q})^2 \, (\frac{ec}{\alpha})^2 \, \frac{2}{\pi} \, \Big(\frac{1}{Ampere}^2\Big) \, c^{-2} \tag{6}$$

where s = geometrized second[1] and $\overline{\Delta q} = 7.714 \times 10^{-27} s^{-1}$ (equal to 71.36 $km/second/Mparsec$, in good agreement with observations free from cosmological model-bias [19]) and one gets from eq. 5

$$(\overline{\Delta q})^2 \, (\frac{ec}{\alpha})^2 \, exp(\frac{-h\nu}{kT}) = \frac{\pi}{2} \, c^5 \, U(\nu) d\nu^{-1} \, \tau^2 \, Ampere^2 \Big(1 - exp(\frac{-h\nu}{kT})\Big) \tag{7}$$

where, additionally, $ec/2\alpha$ is the magnetic charge (cf. [20]) with e being the electric charge and α the fine structure constant.

The factor $\pi/2$ now appearing in the non-local frame has a particular interpretation in the present geometry. Employing the analogy between the Lorentz factor (cf. the inverted x_1 component of the first equation in Appendix I, 17, which applies to the Lorentz contraction of the line increment in the non-local frame as given by $\overline{\Delta q}/s = -v$) and the Wallis product that yields the number $\pi/2$,

$$\frac{\pi}{2} = \prod_{n=1}^{\infty} \frac{2n}{2n-1} \, \frac{2n}{2n+1} = \prod_{n=1}^{\infty} \frac{1}{1-(2n)^{-2}} \; ; \quad cf. \; \Big(\frac{1}{\sqrt{1-v^2/c^2}}\Big)^2 \; ; \; v \to \; 0 \quad \Longrightarrow \quad \Sigma\overline{\Delta q} \approx \overline{q} \approx 1 \; , \tag{8}$$

$\pi/2$ can be regarded as derived from reiterating smaller and smaller line increments in the distal and proximal directions starting at the velocity $v_0 = c/2$ until the local frame of the source and that of the sink are simultaneously arrived at. In the non-local frame, the line increment only exists in the form of the perpendicular velocity and while that decreases during the reiterations the distance between the source and the sink (the radius) increases. This is a numerical operation in a frame that is space-like separated (hidden) from any observer so concerns about the limiting velocity of light are not relevant. In a cosmological context, where the Planck distribution is that of the CMBR, the value $v = c/2$ corresponds to half the radius of the universe at its relativistic horizon and the reiteration of line increments stops at $7.714x10^{-27}m$, the value of the line increment indicated above. Hence, in the present geometry, the local signal observer of eq. 7 redefines the remote radial distance on each quantum observation, cf. [21] [22]. Adding line increments in the local frame until the remote relativistic horizon is reached (eq. 3) defines the environment $1m/s$ of the electromagnetic signal in the present geometry. Such reiterations of lengths do not imply any signal transfer, it is just a quantitative way of assuming that space is on average equivalent along the line of sight from the point of view of the local momentum-observer. This velocity of a light signal ($1m/s$) travelling any arbitrary distance between source and sink can be obtained in the same manner by reiterations of line increments starting from $v = c/2$. The possibility of instant communication between source and sink suggested by the chosen geometrical framework of eq. 8 might be relevant to the phenomenon of standing waves in lasers. There is growing evidence in physics-science for various forms of instant communication (e.g. 'teleportation' and similar phenomena), which has led to an emergent interest in communication through wormholes with in the framework of general relativity. Instant communication is not a main

[1]non-standard notation, the factor c^2 on the right side has the value $1m/s$ in these units

topic of the present work and it suffices to note that events in a space-like separated frame of observation like here may offer a simpler approach to the topic than wormholes. Presumably there is a rich flora of still unknown numerical operations with un-explored physical interpretations that can be performed in the non-local frame.. The present geometrical framework for the first time offers, in place of relativistic length contractions of observations made in the rest frame, an alternative interpretation of the Lorentz factor in terms of number theory with emphasis on that length contractions now instead occur in a space-like separated frame of observation hidden from the local observer (cf. [23] [24]).

The other factors in eq. 7 are interpreted in conformity with eq. 6 applied to the Schrödinger equation ([25] local terms associated with the nucleus left, non-local ones associated with the non-local electron cloud right, by author's convention)

$$\overline{\Delta q}^2 \; (\frac{ec}{\alpha})^2 \; (\frac{\partial}{\partial x})^2 \; \Psi = i \; M_e \; \frac{\partial}{\partial t} \; \Psi(2\pi Ampere)^2 \; s^{-2} \tag{9}$$

The above equation expresses a circular current surrounding the local observer and the current gives rise to magnetic poles in the center. This, of course, applies to the atom. The complex plane indicated by the symbol i has a counterpart in the 'twister' $\pi/2$ in eq. 7.

It is also interesting to reinterpret the exponential term of Planck's equation by using eq. 6, aiming at a deeper understanding of the physical processes taking place while the matter and the field interact. For this purpose, the Ansatz is made that ($m = meter$, r = radius)

$$\frac{r_{proton}}{\pi \; \overline{\Delta q}} = \frac{\pi \; m}{r_{Bohr}} \; . \tag{10}$$

This expression is numerically reasonable taking into account that the proton's radius is not exactly known and depends on by which experimental method it is measured. In the present framework though, the above represents an instance of the line increment being the inverse of the radius (eq. 1) and both are normalized with respect to their non-local counterpart. For the proton radius, that appears to be the curl of the line increment and for the Bohr radius, that is the curl of the unit length which carries per unit time the light signal. This is consistent with the line increment residing in the local frame in proximity to the atomic nucleus like in eq. 9 The value thus obtained is $r_p = 1.439 \times 10^{-15} m$. This quantitative result illustrates that the quasi-topological approach pursued here is informative. Previous estimations based on other geometrical properties herein have given the results $r_p = 1.424 \times 10^{-15} m$ [12] and $p_r = 1.31 \times 10^{-15} m$ [11]. This should be evaluated by reference to an extrapolation of neutron scattering data to one nucleon [26] yielding $\approx 1.31 \times 10^{-15} m^2$. Thus having evaluated eq. 10 one obtains from it and eq. 6 for the exponential factor in eq. 7

$$\frac{\overline{\Delta q} \; m}{r_p \; r_B} \Big(\frac{ec}{\alpha} \; \Big[\frac{1}{Ampere} \Big] \Big)^2 \; \Big[\frac{1}{c^2} \Big] \; \frac{1}{E_{particle}} \; \nu 2\pi \overline{\Delta q}^2 \tag{11}$$

where notably local (read: one-dimensional) terms are collected to the left and notably non-local ones to the right and dimension-correcting factors are written in square brackets. The energy per particle, $E_{particle} = kT$, has an unknown form but it should be composed of potential and kinetic energy as usual such as to interact palpably with the Bohr atom and its nucleus (or their proxies). This can be seen by collecting these terms separately;

$$\frac{r_p \; r_B}{\overline{\Delta q} \; m} \; E_{particle} \quad , \tag{12}$$

which reads that the particle energy contains contributions proportional to the nucleus' and to the electron cloud's parts of respectively the line increment sustaining the former's internal dynamics and

[2] Reportedly, the proton might be somewhat transparent to neutrons so the correct experimental value may be higher. Recent data from scattering of charged particles by protons yield much lower r_p-values, probably due to charge artifacts.

the volume element carrying the light signal that is known to interacts with the latter.

The term on the right side of eq. 11 is most interesting. It has the signature of energy (cf. [13] [14]) and that energy is proportional to the number of times the electric and magnetic fields change direction during an arbitrary time period. $\pi\overline{\Delta q}^2$ may be regarded as a surface element carrying potential energy or an axial vector carrying kinetic energy This term has previously been encountered in tentative boson resonance calculations[3].

The geometrical framework chosen thus enables a tentative intuitive understanding of the physics taking place in the exponential term. Above, the term $\overline{\Delta q} \times m$ (m =meter) substitutes for Planck's constant [9] [10]. As indicated by its context in eq. 7 and 9 and as inferred from the W boson resonances mentioned above and in the footnote, $\overline{\Delta q}/s$ (s = geometrized second) interacts with the atomic nucleus[4] while $1m/s$ interacts with the electron cloud surrounding the nucleus. As a consequence of the contemporary focus on the orbital energy level approach to study radiation-matter interactions little progress has been made to understand how the matter contributes, as recently discussed in an article on the 100 years old so called Abraham-Minkowsky controversy [28] (also discussed in [4]). The photon has been shown to be a mathematical object [29] but no one knows at what stage of the radiation's orbital period it, assumed to be a physical object as well, transfers momentum to the matter. Likewise, in laser research, thermal noise and Brownian motion are often regarded as a nuisance rather than a quantitative factor contributing to a good solution of the research problems. The present formalism offers a hitherto unexplored path to a better understanding of the role of matter interacting with electromagnetic radiation. This can be exemplified nicely by a very interesting corollary to eq. 11 below terminating this paper.

First, however, some wider implications of the mathematical form of eq. 5 will be investigated. Several interdisciplinary applications of this mathematical form have previously been observed by the author [30]. Recently, a mathematical form similar to that in eqs. 5 and 7 has been observed in the radial velocity distribution of stars in spiral galaxies [31] [32],

$$g_{bar} = g_{obs} \left(1 - exp(-\sqrt{g_{bar}/g_{\dagger}})\right) \ , \tag{13}$$

where the original notation is used; $\mathbf{A}: \ g_{bar} = {v_{bar}}^2/R, \ \ \mathbf{B}: \ g_{obs} = {v_{obs}}^2/R$, g_{bar} is called the baryonic acceleration and g_{obs} the observed acceleration, v is the rotation velocity at the corresponding radius, R, and $g_{\dagger}$ is a constant having the value $1.2 \times 10^{-10} m/s^2$. Empirical observations yield that for small values of the exponential factor $\mathbf{C}: \ exp(-\sqrt{g_{bar}/g_{\dagger}}) \ \rightarrow 0 \ \Rightarrow g_{bar} \approx g_{obs}$. Furthermore, it holds at large radii [31] that $\mathbf{D}: \ {v_{bar}}^2/R = GM_{bar}/R^2$ where G is the gravitational constant and M_{bar} is the enclosed baryonic mass such that $\mathbf{E}: \ R = GM_{bar}/{v_{bar}}^2$, and $\mathbf{F}: \ M_{bar} \propto {v_f}^4$ where v_f is the flat velocity, i.e. the velocity measured at the outer edge of the galaxy (routinely however an average flat velocity). This is known as the 'Baryonic Tully-Fisher Relation' and will also be written here as $\mathbf{G}: \ \Gamma M_{bar} = {V_f}^4$ where the proportionality constant Γ has dimension $m^4/(kg\ s^4)$. For the present purposes, the exponential term of eq. 13 is rewritten as

$$\overrightarrow{A} \sqrt{\frac{{v_{bar}}^2}{g_{\dagger} R}} \ \overrightarrow{E} \sqrt{\frac{{v_{bar}}^4}{g_{\dagger} G M_{bar}}} \ \overrightarrow{G} \sqrt{\frac{\Gamma {v_{bar}}^4}{g_{\dagger} G {v_f}^4}} \ \rightarrow \sqrt{\frac{\Gamma}{g_{\dagger} G}} \frac{{v_{bar}}^2}{{v_f}^2} \ \overrightarrow{G} \ \frac{{v_{bar}}^2 \ {v_f}^2}{M_{bar} \sqrt{g_{\dagger} \ G \ \Gamma}} \tag{14}$$

[3]It was found that the W and Z boson masses could be expressed in terms of the line increment squared times π [10] [27]. The W boson is known to be involved together with gluons in u and d quark transitions that occur in nuclei, furthermore, only u and d quarks and antiquarks occur in stable matter

[4]$\overline{\Delta q}/ms$ is interpreted here as a usual 'field' in physics, literally a 'crack' in the vacuum, that manifests itself as an apparent cosmological expansion. The factor $\pi\overline{\Delta q}^2$ may hold the clue to the mechanism by which energy is extracted from this vacuum field.

where one can use the 4:th term above into eq. 13 to verify that $v_{obs} = v_f$ for small values of the exponential factor provided the square root equals one. Based on the above, eq 13 will take the simple form

$$ {v_{bar}}^2[s] = \Big(1 - exp(- K_1 \frac{{v_{bar}}^2 \ {v_f}^2}{M_{bar}})\Big){v_{obs}}^2[s] \tag{15} $$

where the left and right sides have the frame signature of energy like in eqs. 5 and 7. If that analogy holds in a general sense then the absence of an exponential term on the left, local side of eq. 15 is to be expected since the matter is stable whereas an excited atom is not. The exponential term on the right side, by analogy with eqs. 5 and 7, expresses the extent to which the field stabilizes the matter as a function of v_f and v_{bar} and M whereby the latter corresponds to kT (energy per particle) in eq. 5. Additional factors may contribute depending on whether or not the substituted exponential factor $\sqrt{\Gamma/g_\dagger G}$ indeed represents constants, which is not known. An interpretation of gravity in terms of matter-field dynamics like here would lead to a cosmology quite different from the one based on rigid space-time geometry like in GR (cf. [12]) but steps have already been taken in this direction [33] *albeit* still burdened by the now established cosmology. In the present case, the exponential term may be regarded as a quotient of non-local contributions in the numerator (the velocities) by local ones in the denominator (the mass). Hence the mathematical form above suggests that the field contributes less to the equilibrium when the central mass is heavy and more when the velocities are fast, as if the central mass could be saturated with 'gravitons' coming from or staying in the field. This hypothetical situation in some respects resembles stimulated emission as described in [5] or the nucleation of stars from halos as discussed in [34].

Now, remembering that both $\overline{\Delta q}$ and the length $1m$ of eq. 3 implicitly are rates, the corollary to eq. 11 held in promise is that when electromagnetic radiation starts to behave as particles at the transition from Thompson to Compton scattering at about $\nu_0 = 1.3 \times 10^{26} s^{-1} = 4.3 \times 10^{17} sec^{-1}$ the exponential factor of eq. 11 can be written

$$ K_2 \ (\nu - \nu_0)\frac{\overline{\Delta q}^2 \ m^2}{E_{particle}} \tag{16} $$

where $\overline{\Delta q}$ interacts with the baryonic matter and m at large radii (cf. [21] [22]) corresponds to the flat velocity of eq 15. Hence, eq. 7 and 15 are analogous in every respect, galaxies can be considered as an instance of the thermal distribution in a non-local matter field[5] adding to the evidence that the apparent cosmological expansion actually is a kind of vacuum energy as previously proposed.

4 Appendix I (from [25], see also [10], [9])

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:

$$ (q_0, t_0) = \left(\frac{\sqrt{1 - \frac{v^2}{c^2}}}{v}\frac{m^2}{s}, 0\right); \qquad (\bar{q}_0, \bar{t}_0) = \left(\frac{1}{v}\frac{m^2}{s}, -s\right) \tag{17} $$

[5] Why G, $g_\dagger$, $\sqrt{\Gamma}$, and ec/α are of the same magnitude in SI units and why the energy density per m^3 of the local CMBR corresponds to half an electron, having mass and circulating in a non-local form around the nucleus remain open questions.

$$(q_r, t_r) = \left(\frac{\sqrt{1-\frac{v^2}{c^2}}}{v}\frac{m^2}{s}, s\sqrt{1-\frac{v^2}{c^2}}\right); \qquad (\overline{q}_r, \overline{t}_r) = \left(\frac{1}{v}\frac{m^2}{s} - vs, 0\right) \tag{18}$$

$$\overline{\Delta q} = -vs\ , \qquad \overline{\Delta t} = \overline{t}_r - \overline{t}_0 = s \quad \Rightarrow \frac{\overline{\Delta q}}{\overline{\Delta t}} = v \tag{19}$$

$$\Delta q = 0\ , \qquad \Delta t = t_r - t_0 = s\sqrt{1-\frac{v^2}{c^2}}\quad . \tag{20}$$

Here, m is the unit of length and s the *geometrized* unit of time [6]. 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

$$q_r{}^2 + \frac{1}{c^2}\frac{m^4}{s^2} = \frac{1}{v^2}\frac{m^4}{s^2} = \overline{q}_r{}^2 \tag{21}$$

or

$$(\frac{\Delta t}{s})^2 + (\frac{\overline{\Delta q}}{m})^2 = 1 \tag{22}$$

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. 19c.

The sign of the line increment (cf. eq. (19) 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. (17b) and (19a)),

$$\frac{-\overline{\Delta q}}{m} = \frac{m}{\overline{q}_0}\quad , \tag{23}$$

which yields

$$\overline{q}_0\ \overline{\Delta q} = -m^2 \approx \overline{q_r}\ \overline{\Delta q}\quad , \tag{24}$$

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. (19) and (20), 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. (20b)) and can only access the observation *via* eq. 22.

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

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