Space-Time Dimensionality of Plain Physical Observation *

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Abstract. A local Euclidean reference frame, which forms the basis of physical observations, may be defined by reference to some space-like separated frame, in which case a constrained validity of the closure axiom may be implied. For instance, the inverse of the x_1-component of the four-velocity may be Lorentz-transformed to an Euclidean reference frame defined around $t = 0$ whose spatial extension is limited by c. In this geometry, local observations of radial increments are made perpendicular to an angular velocity in a space-like separated frame. The space-time dimensionality of this system is further investigated. Interesting applications seem to be contracting three dimensions on a cosmological scale to a single axis of observation, and the Bohr atom.

INTRODUCTION

The knowledge-theoretical dilemma of distinguishing between the perceived signal and the object itself was in the focus of the academic debate in the late 18:th century but its implications for modern physical descriptions have been taken lightly. For example, all of relativity theory is based on regarding the information carrier light as an approaching object even though it is not. The invariance principle in relativity theory leads to the well-known problems of defining the spatial limitations of the universe, its ”closure” in Euclidean space. Current standard cosmological models are all based on placing celestial objects in a 3-dimensional Cartesian coordinate system subject to relativistic frame invariance. Is the real world really an object looking like a Cartesian coordinate system? No. Atoms, which are the most stable form of matter, are round and electromagnetic radiation has three qualitatively distinct spatial dimensions harboring magnetic and electric vectors and momentum whereby the signal forms a wave front. These qualities are not inherent in the Cartesian coordinate system. Why then should the universe be an infinite object of right angles as required by the invariance principle enforced at each point in a Cartesian coordinate system? Obviously, there is no reason why it should be. In fact, the geometry of the universe is not known. The following is an attempt at finding a

Published on August 31, 2004.

more natural geometry of the physical world where the Cartesian coordinate system is secondary to the qualities of the observers' frames and the latter inherently yield the empirically known geometry. For this purpose, the 200 year-old academic debate mentioned above is revived: Observations are one-dimensionally directed towards the signal rather than towards the physical object and the object itself is made space-like separated from the observer's frame.

RESULTS

Let two observers O and $\bar{O}$ located on the x-axis of a Cartesian coordinate system measure at time t the distance between respectively origo and a point q near the circumference of a circle. Let

$$q_0 = \frac{\sqrt{1 - v^2/c^2}}{v}\frac{m^2}{s} \ ; \quad t_0 = 0 \ , \tag{1}$$

where m is the unit of distance, s is the unit of time (sec is the SI-unit of time) and $c = m/s$ is the velocity of light. The circle is defined by analogy with the unit circle, $(\cos x)^2 + (\sin y)^2 = 1$, as

$$q_0{}^2 + \frac{1}{c^2}\frac{m^4}{s^2} = \frac{1}{v^2}\frac{m^4}{s^2} \tag{2}$$

Then perform a Lorentz transformation to the barred frame such that the observer $\bar{O}$ measures

$$\bar{q}_0 = \frac{1}{v}\frac{m^2}{s} \ ; \quad \bar{t}_0 = -s \tag{3}$$

Define the barred frame to be the laboratory frame and evaluate q and t at a time later by one unit in the barred frame, $\bar{t}_r = 0$;

$$q_r = \frac{\sqrt{1 - v^2/c^2}}{v}\frac{m^2}{s} \ , \quad t_r = s\sqrt{1 - \frac{v^2}{c^2}} \ ; \tag{4}$$

$$\bar{q}_r = \frac{1}{v}\frac{m^2}{s} - vs \ , \quad \bar{t}_r = 0 \ . \tag{5}$$

The sign of the interval, $d^2s = d^2x - d^2t$ as calculated on each of the four coordinates, $q_0, t_0;\ \bar{q}_0, \bar{t}_0;\ q_r, t_r;\ \bar{q}_r, \bar{t}_r$,

$$d^2s_0 = \frac{c^2m^2}{v^2} - m^2, \qquad d^2\bar{s}_0 = \frac{c^2m^2}{v^2} - s^2 \tag{6}$$

and

$$d^2s_r = \frac{c^2m^2}{v^2} + \frac{v^2s^2}{c^2} - s^2 - m^2, \qquad d^2\bar{s}_r = \frac{c^2m^2}{v^2} + \frac{v^2m^2}{c^2} - 2m^2 \ , \tag{7}$$

shows that the observers are space-like separated for all velocities $v < c$ and units $m = s$ whereas in classical relativity, space-like separation follows when $v > c$.

The time interval

$$\Delta\bar{t} = \bar{t}_r - \bar{t}_0 = 1 \tag{8}$$

is an interval of observation located adjacent to zero (=present) time, which is taken as the allowed coordinate from where an observation can be made. The lapse of one unit of time in the barred frame is measured from origo as

$$\Delta t = t_r - t_0 = s\sqrt{1 - \frac{v^2}{c^2}} \quad . \tag{9}$$

The lapse of a unit of time produces a line increment in the barred frame,

$$\Delta\bar{q} = -vs \quad , \tag{10}$$

while the radial distance as calculated from the frame at origo remains the same as before,

$$\Delta q = 0 \quad . \tag{11}$$

The sign of the line increment shows that the radius of the observed object decreases (cf. eq. (5) and (10)). This corresponds to the observer at origo computing a contracted radius $\bar{q}_0$ such that from eq. (1) and (3), $q_0 = \bar{q}_0\sqrt{1 - v^2/c^2}$. Hence, the geometry can be visualized 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. In physics, line increments in the direction of observation are known from the Bohr atom and the cosmological expansion.

An important argument for abandoning the Bohr quantization scheme in favor of the Schroedinger-Heisenberg schemes in the first half of the 20:th century was that the rotation of the electron around the nucleus not could be detected. No classical evidence of rotation could be obtained and the counter-argument that signaling from space-like separated events is forbidden was never presented in the debate at that time. One may infer that a similar situation should apply if the present geometry were applied to the cosmological expansion: No classical evidence of rotation may be anticipated in that case.

To proceed with these applications, factorize the unit of distance, m, into momentum mass, M, expressed in units of 's' and velocity;

$$m = Mv = \frac{\bar{q}_0 v}{c} \Rightarrow M = \frac{\bar{q}_0}{c} \tag{12}$$

such that the classical definition of photon momentum, $p = E/c$, reads $\bar{q}_0 = \bar{E}/c$ and any point on the signal axis may have some momentum relative to the expanding cosmological horizon. Let the line increment, $\Delta\bar{q}$, and the time interval, $\Delta\bar{t}$, represent a fluctuation around respectively $\bar{q}_0$ and zero (cf. eq. (3) and (5)). Further, let the symbol $\bar{h}$ substitute for Planck's constant, $\hbar$, in the present geometry and formulate the uncertainty principle relating to momentum, $dx\ dp = \hbar$, as

$$(-vs)\ (m) \approx \bar{h} \quad . \tag{13}$$

Then, a vacuum fluctuation is expressed as

$$\Delta \bar{E}\ \Delta \bar{t} = (-vm)\ s = \bar{h} \quad . \tag{14}$$

For observations towards origo along the full extension of the radius, the magnitude of the line increment is amplified from $\Delta\bar{q}$ per unit radius to m (this may also be seen from eq. (3) and (10)),

$$\frac{-\Delta\bar{q}}{m} = \frac{m}{\bar{q}_0} \quad , \tag{15}$$

which yields the differential

$$\bar{q}_0\ \Delta\bar{q} = -m^2 \quad , \tag{16}$$

whereby the velocity of light, m/s, limits the radial extension of the geometry to $|\bar{q}_0|$. A local observer may try and apply the Euclidean closure axiom to the line increment, $\Delta\bar{q}$, and use it for constructing a 3-dimensional space of infinite extension including visible and space-like separated regions beyond the apparent remote cosmological horizon. However, in the present case, the extension of space is limited by $v \leq c$ as required by $\sqrt{1 - v^2/c^2}$. The limitation of the validity of the closure axiom is only evident by reference to the space-like separated (invisible) frame at origo.

Because of eq. (10) and (11), observations directly relying on energy transfers on the momentum-signal axis 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. (9)). He is unable to define a spatial coordinate system through observations, which would require repetitive use of some line increment or a measuring rod. However, a relation between Δt and $\Delta\bar{q}$ exists. From eq. (9) and eq. (10)

$$(\frac{\Delta t}{s})^2 + (\frac{\Delta\bar{q}}{m})^2 = 1 \quad , \tag{17}$$

such that by comparison with the unit circle, the non-local time is perpendicular to the axis of observation in the barred frame. This is different from classical relativity where time is measured with reference to the velocities of the objects and light moving along the x-axis and arbitrarily assigned a dimension in Hilbert space with a metric and an observation may be performed from anywhere in four-dimensional space-time.

In order to see if the non-locality of the frame at origo may have any concrete consequences, consider the mathematical form of the Sommerfeld equation describing the absorption-emission spectrum of the Bohr hydrogen atom with relativistic corrections;

$$E_{nj} = M_0 \; c^2 \; \left(1 + \frac{\alpha^2}{\left(n - k + \sqrt{k^2 - \alpha^2}\right)^2} \right)^{-1/2} \tag{18}$$

where E_{nj} is the energy of the emitted radiation, M_0 is the rest mass of the electron, $\alpha = v_e/c$ is the fine structure constant, v_e is the orbiting velocity of the electron, and n and k are quantum numbers. Then make an observation towards origo; $\bar{q}_0 = q_0/\sqrt{1 - v^2/c^2}$, and factorize in this expression from unity using

$$1 = -\frac{\bar{q}_0 \Delta \bar{q}}{m^2} = \frac{v s q_0}{m^2 \sqrt{1 - v^2/c^2}} = \frac{1}{(\quad)\sqrt{1 - v^2/c^2}} \; . \tag{19}$$

the empty bracket indicating a non-zero factor, to get

$$\frac{\bar{q}_0}{ms} m^2 = \frac{q_0}{c} \frac{m^2}{s^2} \sqrt{\frac{1}{\left(1 - \frac{v^2/c^2}{(\quad)(1 - v^2/c^2)}\right)}} \; . \tag{20}$$

where v^2/c^2 is perpendicular to the axis of observation (cf. eq. (2)) in the complex plane and the empty bracket harbors the torsional momentum quantum numbers of eq. (18). q_0/c is equivalent of rest mass (cf. Eq. (12)). The first two factors on the right side thus correspond to those of eq. (18). The term on the left side has dimension frequency times distance squared whereby the relation $\Delta \bar{q} \; m = \bar{h}$ is evident from eq. (10) and eq. (13). Then scale down from cosmological size to the unit radius using eq. (15) and accordingly divide the left side by $\bar{q}_0^2$ to get an interval of observation, $\Delta \bar{q}$, corresponding to the signal on the left side of eq. (18): The magnitude on the left side is made smaller by a factor of $\bar{q}_0^{-3}$ upon transforming from cosmological to atomic size. It may be concluded that eq. (18) and eq. (20) are equivalent up to the quantum numbers but distinguished by scaling of the magnitudes. Thus, if the signal axis is capable of transmitting information about the universe then the primordial hydrogen atom is capable of appearing along with it. The gravitational center of the universe is non-local in the empirical sense that contributions from all directions cancel at any point and the results therefore seem to indicate that this non-locality is made manifest through the existence of (hydrogen) atoms in a frame lacking spatial measures.

In contrast to the hydrogen atom for which exact experimental data long have been established, the geometry of the universe is not known. However the present non-standard approach to cosmology may be evaluated using known numerical data for the apparent expansion rate and other cosmological observables. This is somewhat beyond the scope of an investigation of the plain geometry but is nevertheless highly relevant in any discussion of the Euclidian closure axiom. Hopefully, applying the geometry in various pertinent contexts will yield numerical correspondence with standard cosmological models.

In principle, the expansion rate should be the inverse of the radius of the universe (eq. (15)), from where its matter density may be obtained by conversion from geometrized units. In one particular non-standard approach [1], the energy produced by Λ_0 decay tangential to the cosmological horizon is equated with the line increment as described by

$$\Delta\bar{q}_{length\rightarrow energy} = \frac{E_{\Lambda_0}}{2\ c\ \tau}\ 2\pi\ r_u \quad , \tag{21}$$

where E_{Λ_0} is the energy of the particle, τ is its half life, and $r_u = \bar{q}_0$ is the radius of the universe, which yields $\Delta\bar{q} = 0.7668 \times 10^{-26}$ $m/unit\ radius$. In another approach, the geometry is applied to the Bohr atom with radius $\bar{q}_0$ using the scaling $m_e \propto \Delta q$ described under eq. (20) whereupon the condition $\Delta\bar{q}\ m = \bar{h}$ yields (with e indicating the elementary charge)

$$\Delta\bar{q} = \sqrt{\hbar}\ \frac{\pi}{2}\ \frac{2\alpha}{e\ c} \times Ampere \tag{22}$$

and the value $\Delta\bar{q} = 0.77145 \times 10^{-26}$ $m/unit\ radius$. When further applying eq. (15) and integrating line increments per unit radius until the herein described limitation of Euclidean space is reached, the age of the visible universe appears to be 13.7×10^9 $years$, which agrees in the 3:rd digit with the value recently calculated by the Wilkinson Map Project [2,3]. This result and the fact that the expansion rates are within acceptable limits of current estimations indicate that the present geometry is capable of providing a workable approach to cosmology.

It is noteworthy that not only physical objects are accommodated by this geometry. The signal transmission *per se* is also represented. Electromagnetic radiation is known to be composed of electric and magnetic vectors perpendicular to the signal propagation (as in the frame O, which also is capable of representing polarization and a non-local wave front) while the momentum appears in the direction of propagation (the frame $\bar{O}$).

DISCUSSION

This report describes a geometry, which is closely tied to physical objects and observations. The objects, which are atoms, are represented by a space-like separated frame having circular shape and a rotational velocity whereas the observer perceives the signal coming from the atoms in a one-dimensional frame of observation - the laboratory frame. The observation is made during a short interval of time located around zero. This interval is related to the classical quantum fluctuation described by the uncertainty principle. During the discrete observation of a signal, a radial contraction towards the remote is measured in the laboratory frame, which is pertinent to the electron jumps taking place in the Bohr atom. Since signaling from space-like separated objects not is allowed, the geometry naturally explains why there is no classical evidence of the electron's rotation around the nucleus. Depending on numerical calibration, the line increment towards the remote may also be relevant to the cosmological expansion rate. The geometry yields a one-dimensional universe perceived in the direction of observation towards the signal whereas the objects themselves are space-like separated. If applied on the cosmological scale, the atoms constitute evidence of the non-locality of the gravitational center of the universe, because they appear in the same non-local geometrical construct distinguished only by scaling of the magnitudes. The non-locality of the space-like separated frame at origo can be shown from the fact that it lacks spatial measures in the direction of observation. Measurements there are instead performed on a time axis estranged from classical relativity a) because it is inherently perpendicular to the axis of observation rather than being arbitrarily assigned a dimension in Hilbert space with a metric and b) because observations only can be made from zero time and not from arbitrary time coordinates in four-dimensional space-time. During the observation, a discontinuous Lorentz transformation of this object is performed to the laboratory frame. As a result, two or three spatial dimensions in the object (depending on polarization) become represented in a single spatial dimension in the laboratory frame - the signal axis.

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