Geometry and Particle Number of the Bohr-Dirac Universe *

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Abstract

The particle number in the early universe is estimated by recasting the Bohr atom in the form of the Dirac theory of magnetic poles yielding one atom per unit length per unit curl of current. This requires factorizing out of the Bohr atom a line increment interpreted as the apparent cosmological expansion rate and applying a geometrical model of the universe according to which it is spanned between a momentum observer and a non-local observer as described previously. In the model, CBR generation and the electron shell are conceptually equivalent. Numerical calculations based on CBR, baryon count, particle decay at the horizon, and neutron decay all yield the density 0.5 particles per unit length, corroborating the theory.

Keywords: Bohr atom, Hubble expansion, Dirac string, magnetic monopole, quantum universe, geometry of the universe

1 Results

Special and general relativity theory (RT) when applied to cosmological problems present a shortcoming in that they do not constitute a geometrical object, only an approach to measuring objects. One must, however, consider not only celestial bodies but also the universe itself to be objects. In widely practiced contemporary physics the absence of an object with which to identify the universe is replaced by the so called 'Big Bang' hypothesis. Big Bang cosmology (BBC) is a scenario in which all the energy of the universe was once literally concentrated in a point in space and then exploded, causing the universe to literally expand. Neither RT nor BBC account for the important geometrical features of the physical world that observations only can be made at present time or that an observer located anywhere in the universe must account for the very same universe. These are features that embody non-locality far more profound than currently recognized in electromagnetic signaling, for the entire cosmological horizon which delimits the visible universe must be equivalent for any contemporary observer located anywhere. Furthermore, neither RT nor BBC indicate why stable matter in the universe appears in the form of atoms nor do they relate the signal from atoms to the geometry of space-time. Trying to solve these problems in order to achieve a comprehensive world picture worthy

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of the advances of modern physics seems to be a legitimate research object. In fact, even though the discipline of physics has made enormous progress over the past 150 years the widely held world picture is still mechanistic, having roots in late 16:th and early 17:th centuries. There has been no widely acclaimed breakthrough in this field since Copernicus, Bruno, and Galilei introduced the heliocentric world picture 400 years ago, although quantitative descriptions of the mechanistic universe of course have evolved and improved over the years. In a recent advancement, GRT presents a geometry of space and time accommodating matter identified through its gravitational field. Being a theory of measurement applicable to a variety celestial objects it leaves the important question about the geometry of the universe unanswered.

The present series of papers describes a tentative approach to a geometry of the universe that formally identifies some of the above-mentioned, hitherto little recognized, empirical features. A theoretical and a quantitative approach are pursued in parallel. The theory [1, 2] is based on Lorentz-transforming the inverse of the $\overline{x_1}$-component of the four-velocity at time $\overline{t} = -1$ and $\overline{t} = 0$, representing an interval of observation. This yields a geometrical object in which two observers spatially separated by the radius (of the universe) respectively observe a line increment and measure a tangential velocity. The former observer, who measures momentum, is located at the circumference of a circle while the latter, who measures time, is located at its center. In order to see the entire visible universe any observer must take either of these two observers' place. The momentum-observer sees a one-dimensional world while his counterpart who resides at origo concludes to be located at the center of the universe. Since the two observers are space-like separated and the one at origo is unable to observe momentum, the latter may not be able to actually observe the rotation inferred from computing a tangential velocity. Whereas a classical Lorentz transformation along the axis of observation is known to comprise a boost *and* a rotation, the geometrical object described here attributes the boost and the rotation to separate observers whose frames of observation jointly define the universe.

A classical Lorentz transformation comprising a boost and a rotation precludes a signal velocity greater than that of light and leads to distortions of measurements of objects moving rapidly along the axis of observation. In contrast, information transfer in the form of a rotation of the whole system can, in principle, be instantaneous since the momentum axis then is circumvented. Like in typical quantum phenomena the entire system comprising both source and observer then changes momentarily to the effect that there is no signal transfer from source to observer mediating information about the overall change that has taken place. In contemporary physics, much attention is devoted to phase velocities, which sometimes appear to be supraluminal. The phase of a wave appears among others in the Schrödinger equation and the Dirac string. In the latter case, the string is constituted by a superposition of nodes of a wave and it is generated by a curl [3, 4]. In the theory of strings [3, 5] a closed surface contains one magnetic pole per string and the pole is represented by the quantity $ce/2\alpha$ [4] [1]. Against this background, consider the cosmological expansion rate, $\overline{\Delta q}$, as previously obtained by factorizing out a line increment out of the Bohr atom [6, 7, 8] [2]

$$\overline{\Delta q} = \sqrt{\hbar}\ \frac{\pi}{2}\ \frac{2\alpha}{ec}\ Ampere = 0.7714 \times 10^{-26} s^{-1}. \tag{1}$$

Rearrange this to

$$\overline{\Delta q}\ \frac{ec}{2\alpha} = \sqrt{\hbar}\ \frac{\pi}{2}\ Ampere\ \ s^{-1}, \tag{2}$$

[1] c = velocity of light, e = charge of the electron, α = fine structure constant

[2] A derivation with attention to details can be found in [8] giving $\left(\frac{\overline{2\Delta q}}{\widetilde{s}}\right)\left[\left(\frac{1}{\pi}\right)\left(\frac{ec}{2\alpha}\right)\right]\frac{1}{Ampere} = \sqrt{\hbar}c$

multiply by 4 to obtain (since the geometry yields that $|\overline{q}\overline{\Delta q}| = 1$, where $\overline{q}$ is the radius (of the universe)

$$4 \, \frac{ec}{2\alpha} \, \overline{q}^{-1} = \sqrt{\hbar} \; 2\pi \; Ampere \;\; s^{-1}. \tag{3}$$

Hence [3], one unit curl of current, 2π $Ampere$ s^{-1} as modulated by the Planck length, generates 4 particles per unit length of the radius. These may be interpreted as particles-antiparticles of opposite spin (cf. [3, 5]) One may also limit the curl to π (multiplying by 2 instead of 4 above) in which case two particles of opposite character are generated. Since matter is neutral the equation reads that one atom per meter is created by the unit curl of current. It is also interesting to note in eqs. 2 and 3 that a one-dimensional quantity on the left hand side (the string, cf. [8]) equals a component of curl on the right hand side. This is of particular importance in the context of the present geometry where the line increment per unit length along the momentum axis $\overline{\Delta q}/ms$ equals numerically a tangential velocity v as identified by the non-local observer (cf. [1, 2].

A similar result regarding particle count may be obtained by plain numerical estimations based on the present theory [9]. These estimations are made with the following background: The line increment (which is interpreted as the apparent cosmological expansion) may be added to each unit length along the axis of observation starting from the local observer until at the edge of the universe it sums up to the velocity of light, c [9]. Since signal velocities greater than c are unphysical this defines the radius of the universe. Hence, the geometry surrounds the universe in a 'shell' capable of accommodating mass-less electromagnetic oscillations. From the point of view of the momentum observer the shell is non-local perpendicular to the axis of observation. The thickness of the shell depends on the chosen magnitude of the unit of length. The unit must be chosen small enough in comparison to the radius so that the edge of the universe appears at large radius since a group contraction of the O(3) symmetry group for massive particles into the E(2) group for mass-less particles requires a large radius [10, 11]. Furthermore, it is at large radius where the early universe can be observed that electromagnetic energy dominates in BBC. Hence the geometry harmonizes with some other results achieved in other theoretical settings. The choice of unit length appears conceptually similar to the freedom of choice of gauge or redundancy of phase but obviously some choices of the unit length (those small in comparison with radius) may be more physical than others. In the present theory, oscillations at the outermost edge of the universe so defined are sought to be identified with the CBR [6, 9].

Also the atom presents a shell-like geometry wherein the non-local electron hidden in a 'cloud' surrounds the more massive nucleus. Therefore it may not be a coincidence that the energy density of CBR, 3.44×10^{-58} m^{-2}, and the mass of the electron taken per unit cubic length, $6.764 \times 10^{-4} >$ $m \times m^{-3}$ are so close. On the contrary, in the present theoretical framework this provides the starting point for a numerical estimation of the particle number in the universe: Based on the numbers above the CBR provides 0.51 of the energy required to build one electron per unit cubic length. The matching baryon number is obtained as follows. The radius of the universe (which is the inverse of the local (Hubble) expansion rate, 7.714×10^{-27} s^{-1} [4]), 1.296×10^{26} m is interpreted as its total geometrized mass or energy and divided by its classical volume, $4\pi\overline{q}^3/3$ to obtain its density, 1.420×10^{-53} m^{-2}. Subsequently dividing by the mass of any particle that one considers primordial yields the expected baryon number density in the early universe (from which contemporary atomic nuclei have evolved by nuclear fusion). For example, choosing the proton yields $1.420 \times 10^{-53}/1.242 \times 10^{-54} = 11.43$. It is then necessary to rely on BBC for the fraction of the total density that corresponds to baryons, which currently is estimated at 4.6 % [12]. Hence the number of protons per unit volume that corresponds to the 0.51 electrons/m^3 equivalent of the CBR is 0.53. The ratio of these is invariant with respect to

[3] exponential of q^{-1} inserted on Jan 4, 2011

[4] s denotes the *geometrized* unit of time, a non-standard notation

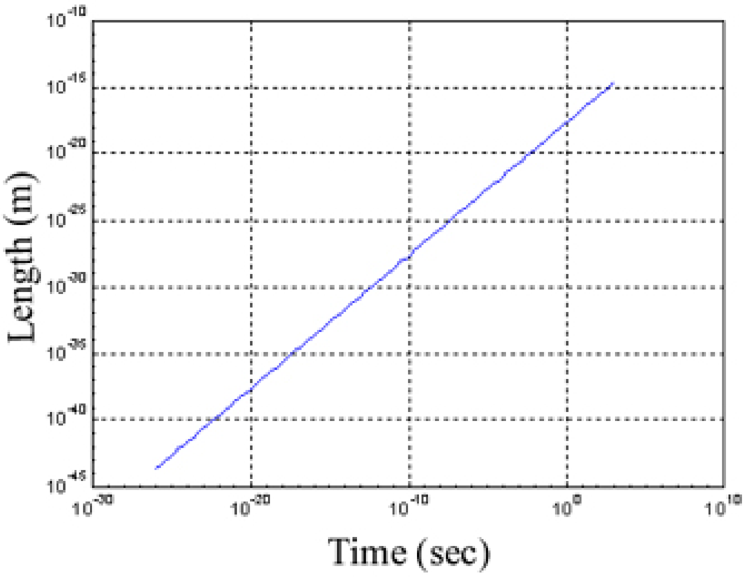

Figure 1: Plot of length (m) versus time (sec, SI-unit) for the apparent expansion rate per unit length, $\overline{\Delta q} = 2.313 \times 10^{-18}\ sec = 7.714 \times 10^{-27}\ s$.

choice of unit. The absolute number density obtained, close to 0.5, is further discussed below in terms of the choice of unit.

Why is the number 0.5 obtained when the theory indicates 1 particle per unit curl ? If one maintains to create the particle(s) by a closed curl 2π [5] one possibility is that half of the expected number of atoms represents antimatter. A second possibility is that some kind of relaxation process or decay has taken place at the cosmological horizon leaving half of the energy as CBR and the other half in the form of electrons. For example, the decay of one Λ_0 particle per qubic metre at the cosmological horizon would be capable of generating 0.5 baryons in addition to CBR of density $7.67 \times 10^{-27}\ m^{-2}$ [9]. The Λ_0 particle is unique among the elementary particles in that it is capable of generating baryons in proportions corresponding to the bulk primordial matter in the early universe. Any CBR generated by such decay from distances less than the radius would have passed the local observer by now (since the radius also defines the age of the universe) and would be on its way back to the horizon. A third possibility of amplifying the number 0.5 by a factor of 2 would thus seem to be that the CBR is reflected from the local observer back towards the cosmological horizon [9], keeping in mind that the corresponding proton count, 0.53, relies on BBC and may be subject to theoretical and/or observational reevaluation. Irrespective of which mechanism is most correct, the primordial atom is a functional unit and it is natural to regard it as *the* quantum of the universe on a unit basis, conforming to the geometry described here. Moreover, it is possible to retrieve the factor 0.5 baryons per unit length in at least one additional context. Namely, if one plots length *versus* time for the expansion rate per unit length (the dimension-less rate s^{-1} has the same numerical value as the tangential velocity $v(ms^{-1})$) one finds the radius of the atomic nucleus ($10^{-15}m$) close to the coordinate corresponding to the half-life of the neutron (Fig. 1). This and other findings [13] suggest that the apparent expansion rate is an active factor in decay processes and reinforces the notion [13] that it should be regarded as a vacuum instability. The finding also illustrates that any quantum process has its own time scale and many such processes will of course take place within one unit of time. It can hardly be a coincidence that the factor 0.5 particles per unit length appears in four entirely different lines of reasoning guided by the same theory.

[5]Dirac actually discusses string generation at half the distance, π

As for the invariance with respect to choice of length measure, consider the example in Fig. 2 and Table I (cf. Appendix) where the measure of length has been amplified to include twice as many particles. Here, the number density per unit radius is of course invariant in any number of dimensions and the geometrized energy or mass density in one dimension is also invariant.

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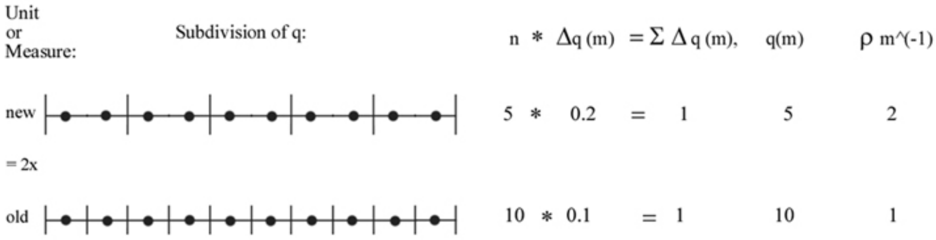

Figure 2: Measures of radius of the universe ($\bar{q}$), length increment per unit distance ($\overline{\Delta q}$), and density (ρ) in proper units when the unit length increases by a factor of 2.

Conversion of	1D	2D	3D
L (m)	1	1	1
$\rho N\ m^{-1}$	2	4	8
$c = (m/s) = 1 \Rightarrow$	1	1	1
$\Rightarrow t(s)$	1		
$kg \rightarrow m, \quad G/c^2(m/kg) \uparrow$	1/2		
$J \rightarrow m, \quad G/c^5(s/J) \uparrow$	1/2		
$\bar{q}(m)$	1/2		
$\overline{\Delta q}(m)$	2		
$\Sigma\overline{\Delta q}(m)$	1		
$\rho_N(\bar{q}(m))^{-1}$	1		
$\rho_N(\overline{\Delta q}(m))^{-1}$	4		
$\rho_N(\Sigma\overline{\Delta q}(m))^{-1}$	2		
$\rho_{kg,J}(\Sigma\overline{\Delta q}(m))^{-1}{=}\rho_N(\Sigma\overline{\Delta q}(m))^{-1} \times (kg \rightarrow m) = 2 \times 0.5$	1		
$\rho_{kg,J}/N(\Sigma\overline{\Delta q}(m))^{-1}{=}\rho_N(\Sigma\overline{\Delta q}(m))^{-1} \times (kg \rightarrow m)/N = 2 \times 0.5/2$	1/2		

Table I. Conversion factors from old to new measures of the indicated entities when the unit length increases by a factor of 2 as shown in Fig. 2 (N=number).

(Appendix)