AN *ADVANCING TIME* HYPOTHESIS

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Abstract

The evolution of the universe is described as an advancement of time, and only collaterally an expansion of space. An interpretation of time as proceeding at the equivalent of *c* across space, perpendicular to space, per a reconsideration of Minkowski's space-time geometry, supports a description of the cosmos as a four-dimensional (hyper) spherical wavefront. By treating space as the surface of a four-dimensional sphere with a current radius of 13.82 billion years (equal to 13.82 billion light years), a Hubble constant of 70.6 (km/s) /Mpc is derived from the measure of the expansion of a megaparsec arc on the surface, independent of empirical measurement or mathematical inversion. It is argued that a close correlation between the advancing temporal cosmic radius and the expansion of the arc subtending a Mpc suggests at least a remarkable coincidence, worthy of further investigation. The hypothesis also has the scientific virtue of economy of explanation, dispensing with the need for the (revived) cosmological constant, cosmic inflation, dark energy, and dark matter as a gravitational constraint on expansion, as well as questions about the shape of the universe and of the influence of gravitation on the rate of expansion. A reexamination of various cosmological parameters in terms of an *advancing time* hypothesis is expected to provide further confirmation and confer greater simplicity and general coherence to cosmology.

Keywords: Cosmology, expanding space, big bang, Hubble constant, Minkowski diagram

Introduction

If the evolution of the universe is primarily an advancement in time and only collaterally an expansion of space, if time is in one aspect motion perpendicular to space (per Special Relativity, the Lorentz transformations, and a revision of Minkowskian space-time, elaborated below), then the universe can be understood as the surface of a four-dimensional (hyper) sphere[1] expanding at the temporal equivalent of *c* in all directions. A calculation treating the age of the universe as the radius of the expanding sphere (equating units of time with *c*) produces an expected value for the Hubble constant of 70.6 km/s for a Mpc arc on the surface. The conception of the universe as expanding in space *because* it is advancing in time offers numerous simplifications of the cosmological model and enables testable evaluations of current parameters and future observations. After *retro-dicting* the Hubble constant from the premise of *advancing time*, a digression on a relativistic modification of the Minkowski diagram provides a theoretical foundation for the hypothesis, and finally, various cosmological parameters associated with the *expanding space* hypothesis are shown to be rendered unnecessary by the alternative.

Main Text

The Correspondence Of t_0 and H_0

One derivation of the age of the universe t_0 is simply taken from the inverse of the Hubble constant H_0 but both numbers have also been measured independently by various means. The following is a derivation of H_0 that has no immediate relationship to t_0, and correlates them without recourse to empirical measurement or prior inference:

Given a four-dimensional (hyper)sphere with a current radius **R** of 13.82 Byr (Calvin, 2013) (= 13.82e9 lyr) advancing at a rate equal to *c* we calculate the circumference **C** as

$$\mathbf{C} = 2\pi\mathbf{R} = 86.\ 83\text{e}9 \text{ ly} \tag{1}$$

and an angle θ subtended by an arc of 1 Mpc along **C** as

$$\theta = \text{Mpc}/\mathbf{C}*360 = 1.35\text{e-}2^{o} \tag{2}$$

The arc subtended by angle θ at radius **R** is given by

$$2\pi\mathbf{R}(\theta/360) = 1 \text{ Mpc} \tag{3}$$

and the rate of expansion **H** of the arc is given by

$$\mathbf{H} = (2\pi(\mathbf{R}+1)(\theta/360)-2\pi\mathbf{R}(\theta/360))\text{k/s} = 70.6 \text{ km/sec} \tag{4}$$

with k = kilometers in a light-year[2] and s = seconds in a year.[3]

Thus **H** is a theoretical derivation from *pi*, the ratio of a Mpc to **C**, and **R**. It is in good agreement with the recent empirical findings of Hinshaw et al (2009) (70.1 ± 1.3), Limon *et al* (2010) (71.0 ± 2.5 and 70.4 +1.3 -1.4), and Riess et al (2011) (73.8 ± 2.4).

Minkowski And Relativistic Time

In order to substantiate the hypothesis of *advancing time* and interpret the correlation between the expansion of an arc on the surface of a 4D sphere with the age of the universe treated as the radius as being more than a coincidence, a discussion of the relativistic concept of space-time and its representation by Minkowskian geometry is necessary, in order to better appreciate the cosmological implications of time as fourth-dimensional motion that is both integral and perpendicular to space.

The prevailing concept of space-time is due primarily to H. Minkowski's geometrical contribution to Einstein's Special Theory of Relativity (1908). Minkowski saw in the relativistic interpretation of the Lorentz transformations[4] the possibility for a two-dimensional representation of the peculiar interrelationships between bodies having large relative velocities. Assuming the validity of the tenets of Relativity, and assuming the correctness of the geometric representation, it was expected that the graphic would express and corroborate relativity in its mathematical form, that "physical laws might find their most perfect expression" (Minkowski, 1908 ,76), thus facilitating further insights into the nature of space-time.

Figure 1 is a typical Minkowski diagram, with the vertical axes of two reference frames representing time and the horizontal axes representing their relative spatial dimensions. A defining characteristic of the diagram is a diagonal vector or vectors projecting the motion of light relative to the motion of an observer who is moving in time on the vertical axis while "at rest" (or moving uniformly) in space.

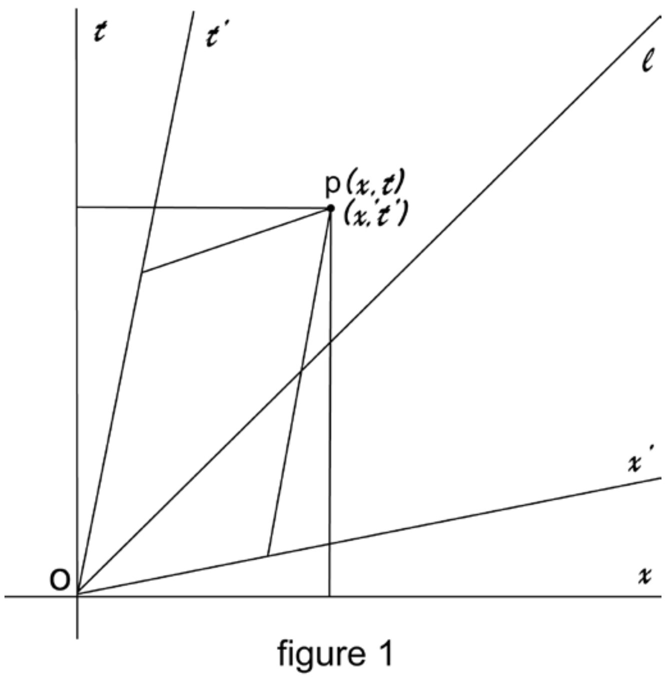

Figure 1: A typical Minkowski diagram. The world-line of the observer is moving in time perpendicular to the space axis. The world-line of a ray of light is depicted as a diagonal in the observer's coordinate system, moving in equal parts of space and time.

There is no more important precept in relativity theory than that in describing the relative motion of a body we must specify the frame of reference from which the observation is being made, and we must distinguish the observed body's metrics of space and time from the observer's. When it is stated, for example, that a body is observed to travel 8 light-seconds (*ls*) in 10 seconds (*sec*), unless we are to return to the absolutes of classical physics we must specify and distinguish according to whose measures of distance and time. To fully describe the observed motion relativistically is to report that the body travels 8 *ls* in space relative to an observer's uniform or stationary spatial reference, and a number of *sec* in time (t') that is relative to the observer's corresponding temporal reference of 10 *sec* (t), at a relative velocity of v (expressed as .8, proportional to c) [5]. The relationship can be expressed by $t' = t(\sqrt{(1-v^2)})$ per Lorentz, or alternately by $t' = \sqrt{(t^2-x^2)}$, with x as the relative distance traveled in space, calibrated in light-seconds and equated with seconds, which in the above example yields either $10(\sqrt{(1-.8^2)})$ or $\sqrt{(10^2-8^2)} = 6$. Strictly speaking, therefore, the body travels a relative 8 *ls* and 6 *sec* (its clock is observed to tick 6 seconds), and we measure its travel from a reference frame of 0 *ls* and 10 *sec*.

The significance of the distinction between the pre-relativistic and relativistic accounts is most striking in the description of light: When it is said in a Newtonian perspective that light travels 300,000 km (1 *ls*) in 1 *sec*, we make a relativistic correction and say, as in the above example, it actually travels 10 *ls* relative to an observer's uniform motion or state of rest in space and 0 *sec* ($t' = 10(\sqrt{(1-0^2)})$ or $\sqrt{(10^2-10^2)}$) relative to the observer's duration of 10 sec in time.

To neglect the relativistic correction is to invite a serious error in one's understanding of space-time, and yet it is an oversight built-in to the Minkowski diagram. The diagonal light-vector in the diagram makes this conclusion unavoidable: To project the world-line of light as moving 10 *ls* in space and 10 *sec* in time (a spacetime diagonal, one side of a "light cone" in the Minkowski diagram) is to describe the relative motion of light in space, but in terms of the observer's own reference in time, treated as an independent, absolute measure. This is a critical misrepresentation of a most fundamental precept of relativity theory -- that time is relative and referential.

An alternative diagram (*figure 2*) conforming to Special Relativity and the Lorentz transformations, and treating both space and time as relative, provides a heuristic representation by means of which, as Minkowski originally envisioned, "physical laws might find their most perfect expression", and the advancing time hypothesis can be most readily comprehended.

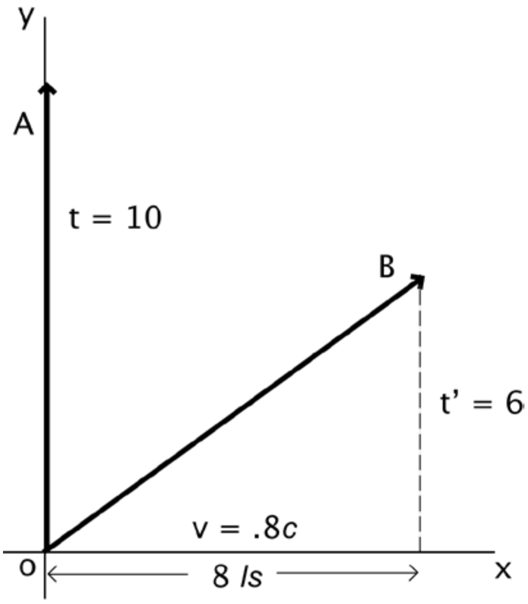

figure 2

Figure 2: An alternative space-time diagram. The world-line of the observed body **B** is projected as moving in time according to its own clock as measured by the observer **A**.

The *x*-axis in *figure 2* represents space, calibrated in light-seconds, while its perpendicular, the *y*-axis, represents time calibrated in seconds -- both according to observer **A**, who is considered to be at rest and moving in time[6] along the *y*-axis. Vector **B** represents a body in motion relative to **A**.

A travels 10 *sec* in time in the scope of the diagram while "at rest" in (i.e., moving perpendicular to) space. Body **B**, which as a matter of convenience is located initially with **A** at the origin **o**, moves from the vicinity of **A** at a velocity, according to **A**, which takes it 8 *ls* in 10 *sec*. The final spacetime coordinates of **B** (8,6) can be derived from a Lorentz transformation, or geometrically by measurement of the lengths in the diagram. By locating **B** at 6 seconds in time it is represented that the clock of **B** has moved 6 *sec* in the reference frame of **A**. (Note that at a velocity of .8*c* the vector of **B** has already transgressed the Minkowskian light-cone.)

The so-called "invariant interval" usually given by $s = \sqrt{(x^2 - t^2)}$ (again, with *x* proportional to *c* and calibrated with *t*), yields a negative square root for relative velocities less than *c*: an imaginary number. But the relationship can be just as well transformed to

$$s = \sqrt{(t^2 - x^2)}$$

and expressed in the example by

$$s = \sqrt{(10^2 - 8^2)}$$

$$s = 6$$

Thereby s, the *interval*, is revealed in the alternative spacetime diagram not as an abstract imaginary, graphically inexpressible, but as a physical quantity, the *proper time*, the observed retardment of the clock of body **B**.

A significant implication profiled by *figure 2* is that there are actually *two* invariants involved in a relativistic relationship: 1) the conventionally recognized interval, reinterpreted here as the proper time of **B** between two events, which is invariant when measured from any reference frame; and 2) the equality of space-time intervals of the world-lines of **A** and **B**. In the Minkowski diagram the world-line of an observer is not recognized as being equivalent in length to the world-line of a body being observed; the latter is treated as the square root of the square of observer's time plus the square of observer's measure of distance traveled ($t' = \sqrt{(t^2+x^2)}$). But in the relationship shown in *figure 2* between an observer and a body in relative motion (now, for the sake of comprehension, substituting s (proper time) for t' and letting t' represent the length of the world-line of **B**, so that $t' = \sqrt{(s^2 + x^2)}$), the space-time interval of the observer (t) can be shown to be necessarily equivalent to any observed world-line:

From the equation (5) for the invariant interval, which was reformulated as $s = \sqrt{(t^2 - x^2)}$ we can derive

$$t = \sqrt{(s^2 + x^2)}$$

which equates t with the hypotenuse of the triangle formed with s and x, and therefore with t', which *is* the hypotenuse. The world-line of **B** is therefore equal in length with the world-line of **A**. We can extrapolate and declare that *all* world-lines (assuming inertial reference frames[7]) must be equal in length with all others for any given period, regardless of the (uniform) coordinate system. This principle will be a factor in presenting the *advancing time* hypothesis in Section IV.

Figure 3 shows two reference frames at once, with **A** and **B** each moving in time perpendicular to space according to their own coordinate system. It depicts, as the Minkowski diagram cannot, the curious phenomenon wherein each observer measures the other's clock as moving more slowly than her own.

Figure 3: Two coordinate systems are shown to mirror their mutual relativistic effects. By rotating the diagram either reference frame can be represented, and the other projected as in relative motion.

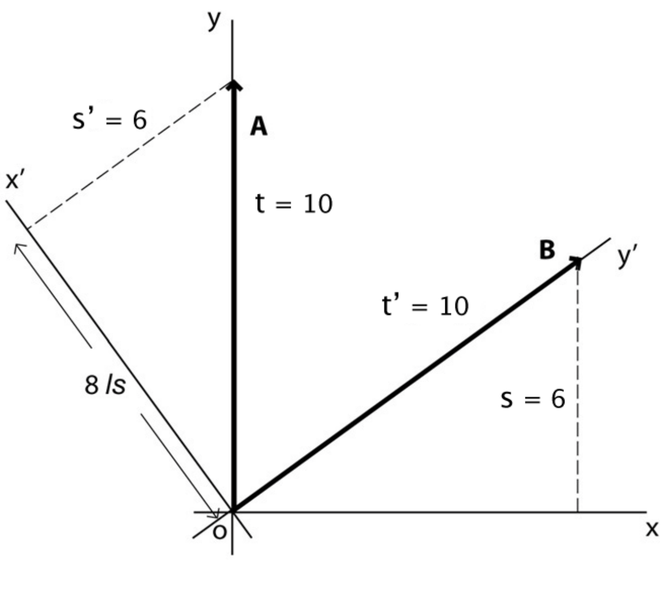

Figure 3: Two coordinate systems are shown to mirror their mutual relativistic effects. By rotating the diagram either reference frame can be represented, and the other projected as in relative motion.

Figure 3 is a fully accurate depiction of the relativistic relationship. It expresses the duality that students of relativity often have difficulty comprehending: Each body has its own orientation in spacetime, and each mirrors the relativistic effects of the other.

Both the Lorentz Transformations and the (modified) equation for the invariant interval indicate a perpendicular relationship between space and time. The motion in time of a body **A** is perpendicular to its orientation in space, and the relative motion of a body **B**, although proceeding in an orientation that is partly temporal, partly spatial according to **A**, is moving in time perpendicular to space in its own frame of reference.

Figure 4 provides a further confirmation of the relativistic accuracy of the alternative diagram, depicting the relationship between an observer and a ray of light.

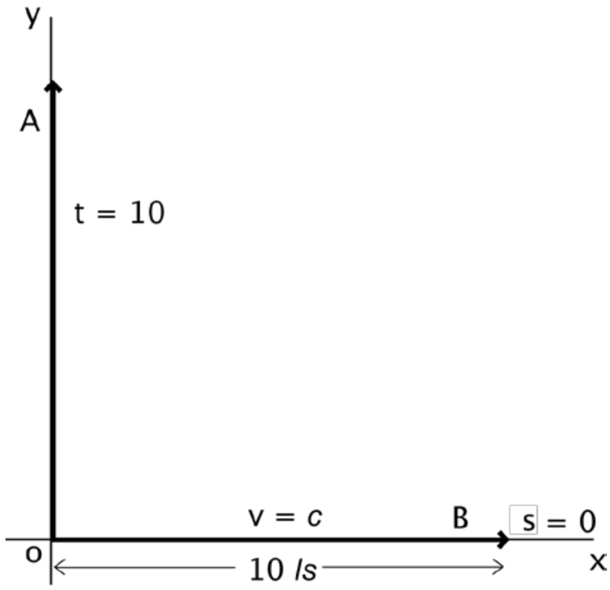

Figure 4: The world-line of a ray of light is projected as moving along the observer's space-axis, conforming to its absence of clock speed according to the observer.

By a Lorentz transformation, the proper time *s* of a body moving at *c* will be measured as zero, and should therefore be projected on a relativistic diagram not as a diagonal (per Minkowski), but as moving directly along the *x*-axis. (*The world-line of light doesn't move in time relative to the observer, therefore it is a misrepresentation to place in on a diagonal, which in effect treats the observer's clock as absolute.*) This alternative representation at once provides a visual explanation for *c* as a limiting velocity (given the invariance of world-lines described above, a vector along the x-axis will have the maximum possible relative extension in space, equal to the observer's extension in time) and an explanation for the invariant measure of *c* (again by the invariance of world-lines, an observer will always measure light as moving as far along the space axis as she moves along the time axis). These aspects of light have remained inexplicable by adherence to the Minkowski diagram, and have prevented the realization of Minkowski's original vision -- that "physical laws might find their most perfect expression" -- in a two-dimensional space-time projection.

An Advancing Time Hypothesis

A fully relativistic space-time geometry as represented by the alternative diagram profiles principles and relationships that have significant implications for cosmology. There is an appreciation of time as a dynamic principle moving perpendicular to space, the invariance of world-lines, and the correspondence of the interval of time with the interval of *c* in space. All of these suggest a heuristic model for re-visioning the evolution of the universe in terms of time rather than space.

As Special Relativity indicates, and as the alternative diagram projects, space and time form a covariant continuum. A body in relative motion has a different space-time orientation than the observer, and moves relatively less in the observer's orientation in time the more it moves in the observer's orientation in space. In order for space and time to be thus inter-penetrable, and related in a way that can be formalized by the Lorentz transformations, time must be a form of motion -- motion in, or more precisely *across* space -- and perpendicular to space in each (non-accelerating) coordinate system, thereby constituting a continuum with space.

It is generally accepted in *expanding space* theory that the universe originated at a singularity. It follows that if time is a form of motion perpendicular to space, then motion of a body in time would of its own nature advance away from such an origin. The singularity would be the immediate *beginning* of time, an *eruption* of time, followed by a continuous advancement. [8] The eruption would initiate a temporal radiation of bodies of mass-energy away from the singularity in all directions, on trajectories evidently determined by the spatial orientation of each body relative to the singularity. (The determination of the basis for a body's initial trajectory is a *metaphysical* question at this point.) In any case, the result would be an expanding four-dimensional (hyper) sphere, with time as the advancing radius (radii) and space as the expanding (three-dimensional) surface constituted by bodies moving in time in all spatial directions.

Given that time is already recognized as dynamic -- as something that moves, that advances -- time would be the determinate, dynamic principles of expansion, that which *must* advance innately, and produce the expansion of space as a correlate.

Indications And Simplifications

An *advancing time* hypothesis is a paradigmatic change of perspective from e*xpanding space*, and as such, it is to be expected that some principles or parameters associated with the *old* would at least initially be problematic in their translation to the *new*. But in addition to its ability to retro-dict the Hubble constant (Section II), the present hypothesis is also creditable by the scientific standard of theoretical simplicity if a number of cosmological factors derived from and required by *expanding space* can be eliminated.

In a sense, *advancing time* doesn't even add itself as a principle of cosmology while eliminating the need for several others. It is already commonly understood that time advances in some manner, it just hasn't been identified as the principle underlying the expansion of space.

Perhaps the most significant theoretical simplification offered by *advancing time* is, with qualifications discussed below, it renders dark energy (Peebles and Ratra, 2003), along with the cosmological constant, quintessence, etc. (which are variously supposed to draw space outward from Singularity with a sort of negative pressure) as unnecessary constructs. Time advances; that's what it does. It needs no extrinsic energy or explanatory principle of any kind.

Gravitation and the total mass of the universe are important factors in *expanding space,* presumably determining variations in the rate of expansion, and posing the question of whether the universe is open and will expand forever, or closed and destined to collapse upon itself. But spatial expansion due to *advancing time* is not affected by gravitation in the conventional sense. In terms of the present hypothesis, a (hyper) surface of co-moving bodies (i.e. all the universe) would be uniformly affected by gravitation due to relativistic time dilation; but when everything is affected the same (local and incidental variations aside), there is no discernable effect on the speed of time at the surface. With time dilated uniformly across the entire (hyper)surface of space, physical processes will always occur at the same rate in the cosmic co-moving time frame, from the earliest moment of temporal eruption to the present time. With the observation, or reception, of light from distant sources those events will appear gravitationally red-shifted due to the relatively greater intensity of the field in the earlier, more concentrated universe. This can help to explain how the mass of the early universe could have overcome extreme gravity without some exotic influence: Even at the very beginning, what we would observe from our present frame of reference as an almost infinite slowing of time due to the immense concentration of mass-energy would, in that primal, universal reference frame, have transpired no more slowly than now.

Ironically in this view, cosmic gravity doesn't cause a deceleration of spatial expansion, it causes relative (but only relative) *acceleration*. This of course conflicts with the recent interpretation of Riess *et al* (1998) that the expansion of the universe must be absolutely accelerating, which has been attributed to an unobserved negative or vacuum energy of some kind. We posit instead a duality of constant expansion among co-moving bodies on the surface of the (hyper) sphere and an acceleration relative to the information carried on the redshifted light received from a distance in the earlier, denser cosmic gravitational field. [9]

The universe would thus be both advancing and accelerating, but with an acceleration only relative to the information received from earlier events.

A great deal of attention in *expanding space* theory is given to the question of how much total mass-energy there must be, and how it would affect the shape of the universe and its rate of expansion. It is important to remember that according to General Relativity, gravitation bends light but dilates time, so with *advancing time* the shape and rate of expansion are entirely determined by "the speed of time" (*c*), independent of the quantity of mass-energy. Indeed, the size and shape of the universe would be the same no matter how much mass-energy it contains: Its shape would in any case be four-dimensionally spherical and three-dimensionally flat.

With time as the dynamic of expansion there is no need hypothesize cosmic inflation (Guth, 1981) to solve a "horizon problem", to account for the observed isotropic large-scale structure of the universe. All cosmic mass-energy advancing in time perpendicular to the singularity would be inherently isotropic; the early universe needn't be "causally connected" if it is expanding at c in all directions and four-dimensionally perpendicular to Singularity. Similarly, Dicke's (1970) "flatness problem" -- comprehending how the density of matter in the early universe could be so precisely balanced to produce a Euclidean geometry -- is solved because a 4D (hyper) sphere expanding in time will do so regardless of the density of mass-energy.

Conclusion: A Big *Time*, not a Big *Bang*

The hypothesis that the universe is expanding in space because it is advancing in time should be considered credible on several counts, and worthy of further investigation and testing.

The rate of cosmic spatial expansion has been shown to relate to the age of the universe by a function of *pi* and the ratio of a given arc to the circumference of a (hyper) sphere -- a highly unlikely correspondence if not due to an actual four-dimensional relationship of time as the radius of a three-dimensional spatial surface. The scientific standard of simplicity of explanation favors a hypothesis that eliminate the need for a number of principles required by an established theory, and *advancing time* has been shown to be needless of a cosmological constant, dark energy, the cosmic gravitational function of dark matter, cosmic inflation, and an extrinsic explanation for cosmic flatness.

Several tests of the hypothesis can be envisioned. It should be possible to confirm that the volume of the universe (a three-dimensional surface, not a four-dimensional volume, somehow incommensurable with the measure of the surface of a sphere of four spatial dimensions) can be derived from a calculation of the surface of a (hyper) sphere of radius **R** (13.82 Byr or Bly), and that the three-dimensional volume is much smaller than generally believed. From the present mass-energy density of the universe it should be possible to confirm that the gravitational component of cosmological redshift is consistent with expectations in terms of *advancing time*. And treating the universe as a (hyper) spherical wavefront rather than a spatial volume -- shaped by the isotropic and uniform advancement of time rather than the quantity of mass -- can be expected to allow a re-calculation of total mass-energy that doesn't require the positing of dark matter as a gravitational restraint.

End Notes

1. A hypersphere is generally defined as consisting of *n* spatial dimensions. The four-dimensional (hyper) sphere described here includes the temporal dimension, a dynamic dimension fundamentally different than, although correlative with, the spatial dimensions.

2. Kilometers in a light-year: 9,460,730,472,580.8

3. Seconds in a year: 60*60*24*365.25 = 31,557,600.

4. The Lorentz transformation for relative time is $t' = t(\sqrt{(1-v^2)})$, with *t* as observer's time and *v* as relative velocity proportional to *c*.

5. As a matter of convenience *t* is generally multiplied by *c* so that space and time can be expressed in distances of the same scale. I believe it is more useful to calibrate them by giving time in seconds (*sec*) and space in light-seconds (*ls*).

6. It is permissible to say a body "moves" in time because space-time has been recognized (by Minkowski, in the first place) as a continuum, as a corollary of Special Relativity. Duration in one coordinate system is a composite of motion in space and time according to another.

7. Inertial acceleration and local gravitational influences are incidental, and need not be considered here.

8. From a universal perspective, given the principle of invariant world-lines, time is in one aspect absolute (again, disregarding gravitation and accelerations). The motion in time, if a body is moving uniformly, is universally invariant, although relative in its space-time orientation as observed from other frames of reference.

9. The light is redshifted due both to the emergence from the universal gravitational field and to spatial expansion; the former aspect appears to express an acceleration, the latter a constant.

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