Observed Background Radiation as a Basis for Determining the Age of an Expanding Hypersphere

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Abstract

This paper examines the extent to which a simple expansion of the space-focused global model introduced earlier by the authors can serve as a useful basis to characterize background radiation attributes of the physical universe. Space-time is modeled as a closed dynamically expanding hyperspherical system. This model is used as a constraint-bound analysis vehicle to determine the age of the system as a function of observed cosmic background radiation temperature and other constraint conditions that are peculiar to both basic physics and the physical universe. Analytical results are presented to demonstrate the mutual consistency of observed attributes regarding (1) apparent flat space-time ($\rho_m \approx \rho_c$), (2) cosmic background radiation temperature ≈ 2.73 K, and (3) age $\approx 17.2 \times 10^9$ yr when viewed locally by an observer within such an expanding hyperspherical system. A variety of cross-checks are made to validate the consistency of these results. Constraint conditions employed include (1) conservation of energy, (2) special and general relativity, (3) quantum mechanical observational limits (Planck time T and length L*), (4) various cosmic background radiation (CBR) attributes [2.73 K at age T = now, a flat space-time blackbody reference locus at 3×10^5 yr for $H_0 \approx 50$, continuous observability, flat space-time mass to radiation energy density ratio ($\rho_m/\rho_r \approx 10^4$) at age T = now], and (5) conservation of locally observed CBR luminal flux. The results also imply that the conversion of CBR radiative energy to mass form is a necessary consequence of requiring the locally observed impacts of space-time curvature caused by system expansion to be energy-balanced globally.*

Key words: cosmic background radiation, Riemannian curvature, age of the universe, Friedmann–Lemaître framework, global model, flat space-time, Einstein–de Sitter universe, critical mass density, expanding hypersphere, big bang, Euclidean space, cosmology

1. INTRODUCTION

Prior papers[1,2] by the authors describe a new expanding hyperspherical space-time model that is used to analyze photon trajectory locus in such a framework. The model may be viewed as an implied topological derivative of the global models developed by Penrose and Hawking for Friedmann–Lemaître-based expansion systems. Discussion is also given in these papers characterizing the distortion impact of photon trajectory on a local observer's view regarding (1) cosmological observability, (2) cosmic background radiation (CBR), and (3) quasar observations. Special focus is put on the ability of the model to correctly predict the distance and age features of high redshift quasars and the general relativity consistency of the analysis results. As a continuation, this paper will extend the scope of the discussion to include the age of the expanding hyperspherical space-time system. Results are presented to demonstrate how observed CBR and other supporting constraints may be used as a basis to predict an age for such a system that is in close agreement with that of the physical universe.

Published literature regarding the age of the physical universe strongly favors an age T in the range

$$10 \times 10^9 < T < 20 \times 10^9 \text{ yr} \tag{1}$$

and a space-time framework that is essentially flat.[3-8] There is some disagreement among various disciplines, however. Many cosmologists exhibit a strong affinity for closing the universe and therefore prefer the lower half of the age range. Stellar astronomers, on the other hand, motivated by star cluster age predictions, frequently prefer the upper portion of the range. The lack of agreement between these two camps suggests a deficiency in the space-time fabric of the "standard model" employed to interpret cosmological observations. The results presented in this paper will seek to reconcile observed stellar age with that of cosmology by resorting to a dynamic exterior perspective hyperspherical space-time viewpoint.

The simple hypothesis considered in this paper is as follows. Given a closed expanding hyperspherical system with processes that are constrained by (1) initial conditions consistent with quantum mechanical limits on time and length (Planck time T^*

and length L^*), (2) special and general relativity, and (3) conservation of energy, are the local observations regarding (1) CBR, (2) Riemannian space-time curvature, and (3) age consistent within the context of the model? Are they in agreement with observed attributes of the physical universe? In the case of the commonly accepted flat space-time standard model it is well known that its local analysis viewpoint regarding CBR is at odds with conservation of energy.[9] As indicated above, its Riemannian curvature-based gravitational drag on Hubble expansion also does not agree with observed data on physical age. Further evidence of an ill-posed nature is encountered when one notes inflationary model violations of thermodynamic laws.[10] On the other hand, if one is willing to interpret local cosmological observations as relativistically distorted space-time representations of a dynamically expanding hyperspherical background process, as will be demonstrated, consistency can be salvaged.

The specific constraint conditions against which consistency will be tested are as follows. It will be assumed that at the point in time when the age of the hyperspherical system is Planck-time old, that is,

$$T(0) = T^*, \tag{2}$$

the radiation energy state in terms of wavelength is defined by the maximum energy level permitted by quantum mechanical limits, that is,

$$\lambda(0) = L^*, \tag{3}$$

Planck length. As postulated in the theory of relativity, the speed of light will be constrained to be a constant value c, which is unaffected by the state of motion of an observer. It will also be required that the dynamic and geometric character of the model for local frames of reference be asymptotically compatible with general relativity equations which correspond to flat space-time[4]:

$$(\dot{a}/a)^2 = (8\pi G\rho + \Lambda)/3 - k/a^2, \tag{4}$$

where the Hubble constant $H_0 = \dot{a}/a$, the mass density ratio $\Omega = \rho_m/\rho_c \approx 1$, the critical mass density $\rho_c = 3H_0^2/8\pi G$, the cosmological constant $\Lambda \approx 0$, and the curvature index $k = 0$.

Conservation of energy will be satisfied globally in the model by accounting for (1) gravitational field energy and (2) conversion from radiative form to decoupled matter form in terms of a redshift reduction of observed background radiation temperature. Thus observed background radiation in the system at age T is

$$\rho_r = \rho_r' - \rho_m, \tag{5}$$

where ρ_r' is the hypothetical (no-mass) radiative energy density, and ρ_m is the decoupled mass–energy density (including the gravitational field energy component) at age T. Since the analysis deals with observed CBR as a vehicle for determining the age of the hyperspherical system, the use of energy balance-based temperature shift is especially convenient.

A number of observed data points drawn from the physical universe will also be employed as constraints. These include energy density ratio for mass and radiation as well as several specific attributes associated with the big bang cosmic background radiation itself. Mass energy to radiation energy density ratio for the current age (T = now) of the physical universe as dictated by an observed flat space-time requirement[11] for $H_0 \approx 50$ is $\rho_m/\rho_r \approx 10^4$, $\rho_m \approx \rho_c$.

The specific CBR attributes of interest are observed temperature and age of the universe corresponding to the perimeter locus of the observed blackbody radiator. Recent COBE satellite observations have established the observed radiation temperature as 2.73 K and the blackbody perimeter locus (where scattering essentially ceases) is commonly stated[12] as approximately $t_p \approx 3 \times 10^5$ yr (assuming Hubble expansion $H_0 = 50$ in flat space-time). This flat space-time reference value for t_p will be perturbation-corrected using the formula[11]

$$\begin{aligned} t_p(\text{spher}) &\approx t_p(\text{flat})\,[H_0(\text{flat})/H_0(\text{spher})]^{-4} \\ &\approx 3 \times 10^5\,(50/H_0)^{-4}, \\ H_0 &\approx 0.98 \times 10^{12}/T\,(\text{yr}) \end{aligned} \tag{6}$$

to adjust for change of H_0 in going from a flat to spherical space-time topology. It will also be required that locally observed CBR luminal flux is conserved as the hyperspherical space-time system expands. A topology-independent age expression based on conservation of luminal flux will be used to determine the perturbation correction in t_p cited above.

The foregoing constraint conditions will be applied in various combinations in analyses aimed at determining the age of the expanding hyperspherical space-time system. First, however, the attributes of the "exterior perspective" space-time model will be reviewed.

2. HYPERSPHERICAL SPACE-TIME MODEL

The space-time model used here is described in a prior paper by the authors.[2] It is recommended that those who are not familiar with it read that paper before proceeding with this one. The model is fundamentally a 4-space hypersphere that is expanding radially along its imaginary temporal axis. The topology of this structure corresponds to a derived set of exterior-perspective space-time properties implied by Penrose–Hawking general relativity-based global models for Friedmann–Lemaître big bang systems.[13–18] These time-reversed black hole-based models require that such systems from an exterior perspective be spherical. As shown in the 2-space diagram of Fig. 1, a photon trajectory in the expanding hypersphere always follows an outward logarithmically spiraling curve. This gives rise to "lens effect" distortion in the field of view seen by a local observer on the locus of the "now" hypersphere. The impact of this space-time curvature-based distortion on observed CBR temperature will be explored in the next section.

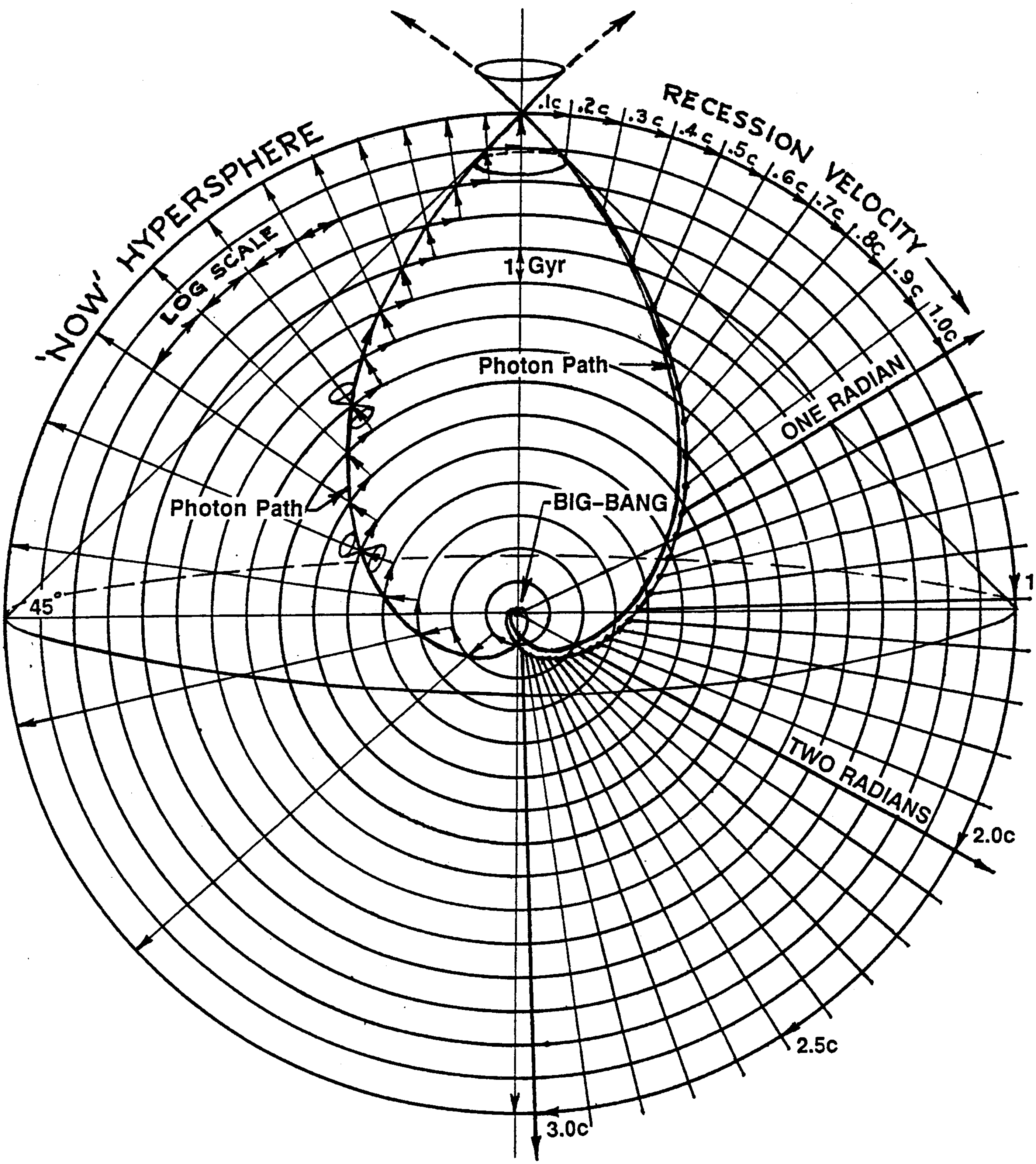

Figure 1. Expanding hyperspherical system as seen in 2-space.

One of the peculiar properties of the exterior-perspective space-time structure shown in Fig. 1 is that its rate of expansion radially along the temporal axis is uniquely constant at the speed of light, c. This is a necessary condition to assure that the derived Hubble rule for the model maintains a linear relationship between the locally observed distance to a distant object and its observed redshift factor. It also contributes to assuring the consistency of light cone topology in the global model with the dictates of general relativity locally. Thus gravitational drag, which plays such a prominent role in local analysis-based "standard model" cosmology, is conspicuously absent at the global level. The consistency of this unusual attribute with the other constraints defined earlier will be tested in the next section.

A second point to be noted concerns the nature of the observer's local framework imposed by the model. The light cone topology at every point of a photon trajectory must asymptotically correspond to that of locally observed flat space-time. Thus all light cones are required to form a 45° angle locally at every locus of a photon trajectory in the expanding hypersphere,[2] and the local framework is forced to be asymptotically flat as a measure of distance, $s \to 0$. In turn, if one assumes that the flatness attribute observed locally exists everywhere, then this implies compatibility with a local framework which corresponds to an Einstein–de Sitter universe with

$$\rho_m = \rho_c \approx 5 \times 10^{-31}\ \text{g/cm}^3. \tag{7}$$

Since the expansion rate of the hypersphere is independent of ρ_m, the impact of $\rho_m = \rho_c$ is evident only in terms of ρ_m/ρ_r. The validity of this attribute will also be tested analytically and quantitatively in the next section.

As indicated in Ref. 2, an observed distant object on a past hypersphere at angle ϕ relative to an observer will be projected onto the observer's now hypersphere with observed recession velocity $c\phi$ and redshift factor $z = \phi$. This distortion is the result of a curved photon trajectory. The model thereby provides a basis for the well-known Hubble rule regarding redshift and distance, but with natural facility to support $z > 1$. Because of the relevance of a "great circle" geodesic path concept, one can define a distance metric in terms of ϕ and t in 2-space as

$$ds^2 = c^2[t^2 + (\exp \phi)^2]/2\, d\phi^2. \tag{8}$$

If a local observer in the expanding hyperspherical system were to assume the existence of flat space-time and a local clock reference, the photon path curvature-caused distortion could be interpreted as an apparent change in system expansion rate

$$c' = c \exp(\phi), \tag{9}$$

which suggests an inflationary beginning to the expansion process from a local perspective. Thus the hyperspherical model inherently provides a natural basis for an "inflationary universe"[19,20] by representing it as a locally perceived artifact of its topology.

Use of the Penrose–Hawking global model baseline allows one to associate the results derived from the model with the underlying general relativity solutions for Friedmann–Lemaître expansion systems. The derived results involving photon trajectory locus can therefore be viewed as logically equivalent to relativistic solutions regarding locally perceived space-time curvature. As will be demonstrated (once again), exploitation of the topological properties of the global space-time structure allows one to obtain solutions regarding observed relativistic space-time curvature with significantly reduced analytical effort.

3. ANALYSIS

Analytical results will now be presented using the hyperspherical model to compute the age of the expanding system as a function of observed CBR temperature, ρ_m/ρ_r, and the other constraints defined in the Introduction. The age of the system will be determined using two different viewpoints regarding CBR redshift: (1) that derived from a global system energy-balance perspective and (2) that of an observer in the local framework. Use of the two baselines will provide some measure of cross-check on the consistency of the results.

Conservation of energy has been assumed as a constraint condition for the analysis presented here. Thus one can surmise that a system level redshift correction from an energy balance viewpoint should agree with that observed in the local framework. In the local framework it is necessary to account for the impact of perceived space-time curvature as well as that related to energy form conversion. At the global level, however, the only identifiable redshift phenomenon that can serve as a basis for supporting this equivalence is that associated with radiation-to-mass energy conversion. This implies an intimate relationship between the causes of that energy conversion and locally perceived space-time curvature. The results given here support such a notion.

In order to develop an expression that defines the impact of converting energy from radiative to decoupled mass form (within a conservation of energy context), it is convenient to consider the expanding space-time structure as a cavity-like structure in which

$$\lambda_2 = \lambda_1[(V_2 - V_1)/V_1]^{1/3}, \quad V_2 \geq V_1, \tag{10}$$

where λ_1 and λ_2 are wavelengths of average radiative energy at states of expansion corresponding to 3-space volumes V_1 and V_2, respectively. This allows one to associate the change of volumetric expansion with a redshift factor

$$z + 1 = \lambda_2/\lambda_1 = [(V_2 - V_1)/V_1]^{1/3}, \quad V_2 \geq V_1. \tag{11}$$

A similar concept can therefore be employed to characterize the impact of converting radiative energy to mass form. By viewing the reduction of ρ_r due to an increase in ρ_m as equivalent to a volumetric spreading of radiative energy, one obtains the topology-independent expression[11]

$$z_G + 1 = \lambda_2/\lambda_1 = (\rho_m/\rho_r)^{1/3}, \quad \rho_m \geq \rho_r. \tag{12}$$

Thus ρ_m/ρ_r, a 3-space volumetric-focused energy density ratio, can be interpreted as implying a 1-space focused redshift factor z_G. Using the observed flat space-time implied value of $\rho_m/\rho_r \approx 10^4$, one obtains a quantitative topology-independent global system redshift factor at

$$T = \text{now of } z_G\,(T = \text{now}) \approx 20.5 \tag{13}$$

for the radiation-to-mass conversion process. Aside from redshift associated with radiative energy spreading due to the expansion process itself, this value should also be valid for observed CBR in the local framework.

Viewed strictly as a locally defined process, observations on the CBR in the local framework appear to undergo significant redshift as a result of a spiraling photon trajectory[2] in addition to that directly attributable to mass–energy conversion. Locally observed CBR redshift can therefore be characterized in terms of two components: (1) z_{PPC} for redshift caused by a spiraling photon trajectory between the locus of the observer and that of a radiating blackbody surface at the apparent "fireball" perimeter and (2) z_{MEC} for redshift due to mass–energy conversion occurring largely at the region of the blackbody. This latter component will be characterized as an effective reduction in blackbody temperature. Assuming that a local observer cannot see beyond the apparent blackbody located at t_p, one obtains a redshift component of

$$z_{PPC} = z_T - z_{t_p} = \ln T - \ln t_p \tag{14}$$

due to the impact of a curved photon trajectory.[2] Quantitatively at T = now ($\approx$15 - 18 Gyr) for $t_p \approx 300\,000$ yr and $H = 50$, this yields an initial estimate[2] (which must be H_0 value gauge-adjusted) of $z_{PPC}\,(T = \text{now}) \approx 11$. This provides a correction to account for the observer's relative state of motion in the local framework due to the dynamic nature of the system. The blackbody radiation source at the t_p location, on the other hand, can be expected to exhibit a Stefan–Boltzmann law-based surface temperature reduction in connection with energy conversion. In this case, the radiated energy density follows a fourth power law as a function of temperature τ:

$$\rho = a\tau^4. \tag{15}$$

In turn, this implies an alternative relationship:

$$\tau_1 = \tau_2[(\rho_2 - \rho_1)/\rho_1]^{1/4} = \tau_2(\rho_m/\rho_r)^{1/4}, \qquad \rho_2 \geq \rho_1,\ \rho_m \geq \rho_r. \tag{16}$$

The redshift correction for radiative to mass–energy conversion, as seen locally, should then be

$$z_{MEC} + 1 = (\rho_m/\rho_r)^{1/4},\ \ \rho_m \geq \rho_r, \tag{17}$$

which means that at T = now, $z_{MEC}\,(T = \text{now}) \approx 9$. Summing both components, the total (topologically dependent) redshift seen locally at T = now is $z_L\,(T = \text{now}) = z_{PPC} + z_{MEC} \approx 20$, which is rather close to the global value for z_G. Regarding the 2.5% difference between the two, if one accepts the value of ρ_m/ρ_r as correct, it can be suspected that the difference is due to a violation of the t_p locus formula given in Eq. (6). This would imply that the value of the H_0 value associated with $z_{MEC} \approx 9$ is not consistent with that for $z_G \approx 20.5$. It will be demonstrated shortly that this is the case.

The close agreement between the quantitative values of z_G and z_L at T = now suggests the general equivalence of the two redshift variables. A basis for such equivalence appears to stem from the fact that both the length and time flow of an observed object at relative locus ϕ are enlarged by the same factor[2] $\exp(\phi)$. This implies that redshift recession velocities seen locally remain undistorted. Thus it can be argued that the local framework redshift due to "lens effect" distortion must exist globally as a component of the redshift attributed solely to energy balance. The energy balance-based blackbody radiator temperature redshift must be another. In this case, the equations for redshift given in Eqs. (12), (14), and (17) may be collected together to obtain an expression that defines the relationship between ρ_m/ρ_r and the age of the expanding hyperspherical system, T, as

$$(\rho_m/\rho_r)^{1/3} = \ln(T/t_p) + (\rho_m/\rho_r)^{1/4},\ \ \rho_m \geq \rho_r. \tag{18}$$

Rearranging algebraically, this yields the hyperspherical model-dependent expression for system age:

$$T = t_p \exp[(\rho_m/\rho_r)^{1/3} - (\rho_m/\rho_r)^{1/4}],\ \ \rho_m \geq \rho_r. \tag{19}$$

This expression will be evaluated quantitatively after an H_0 corrected value of t_p has been determined using Eq. (6).

A model-independent expression for system age can be developed by invoking conservation of observed CBR luminal flux in the expanding hypersphere as a constraint condition. This suggests that the locally observed CBR wavelength follows an inverse square relationship as a function of system age (and temporal radius $r = cT$) during the expansion process. Analytically, this implies

$$\begin{aligned} \lambda_{CBR} &= (z + 1)(r/r_{init})^{-2}\,\lambda_{init} \\ &= (z + 1)(cT/cT^*)^{-2} L^*, \end{aligned} \tag{20}$$

where z is a redshift factor to correct for energy conversion (and locally observed space-time curvature), and $\lambda_{init} = L^*$ at $T = T^*$ corresponds to the quantum limits defined in Eqs. (2) and (3). Thus, according to Eq. (20), if no conversion of CBR radiative energy to mass occurred (i.e., $z = 0$), the locally observed CBR temperature would follow a simple inverse square law reduction as a function of system age T. The $(z + 1)\lambda_{init} = (z + 1)L^*$ term in Eq. (20), when interpreted in terms of the global and local redshift values z_G and z_L, respectively, therefore corrects the initial energy state $\lambda_{init} = L^*$ to account for radiative to mass–energy conversion.

Equation (20) can be rearranged to define system age T as a function of observed CBR wavelength and the quantum-based initial conditions defined in Eqs. (2) and (3). This yields the (speed of light limited) constraint subset derived expression for age:

$$T \approx [\lambda_{CBR}/(z + 1)L^*]^2 T^*, \quad (21)$$

where for T = now, $\lambda_{CBR} \approx 1.1 \times 10^{-1}$ cm (i.e., peak energy density for 2.73 K), and $L^* \approx 1.616 \times 10^{-33}$ cm, and $T^* \approx 5.39 \times 10^{-44}$ s. Evaluating Eq. (21) quantitatively with $z = z_G = 20.5$, the constraint subset-dependent age for the system at T = now is therefore

$$T_G \approx 5.40 \times 10^{17}\ \text{s} \approx 17.1 \times 10^9\ \text{yr}. \quad (22)$$

This, in turn, implies an $H_0 = 57.3$ value and a CBR-based blackbody perimeter locus [via Eq. (6)] of $t_p \approx 1.74 \times 10^5$ yr. Use of this guage-corrected t_p value in Eq. (14) then yields updated values of $z_{PPC} = \ln T/t_p \approx 11.5$ and $z_L \approx 20.5$. In this case, the age expression in Eq. (21) using the corrected locally determined redshift value z_L quantitatively for T = now also yields an age of

$$T_L \approx 5.40 \times 10^{17}\ \text{s} \approx 17.1 \times 10^9\ \text{yr} \quad (23)$$

for the expanding hyperspherical model.

The age of the hyperspherical system per Eq. (19) can also be evaluated using the corrected value of $t_p \approx 1.74 \times 10^5$ yr implied by $H_0 = 57.3$. In tabular form this yields:

Table I: Hyperspherical System Age per Eq. (19)

ρ_m/ρ_r	z_{PPC}	*Age T (yr)*
1	0	1.74×10^5 ($T = t_p$ corrected)
10	0.4	2.6×10^5
10^2	1.5	7.8×10^5
10^3	4.4	1.4×10^7
5×10^3	8.7	1.1×10^9
10^4	11.5	17.2×10^9 (T = now)
10^5	28.6	4.7×10^{17}

The data in Table I indicate that 50% of radiative energy has been converted to matter form at the $T = t_p$ blackbody perimeter locus. Thus the expanding hyperspherical model supports a decoupled mass form conversion rate which is consistent with cessation of scattering at that vicinity. Table I also indicates that when $\rho_m/\rho_r \approx 10^4$, the flat space-time value associated with T = now and $\Omega = 1$ in Eq. (4) for $H_0 \approx 50$, that $T \approx 17.2 \times 10^9$ yr and $z_{PPC} \approx 11.5$. This age value agrees with those given in Eqs. (22) and (23) within the limits imposed by the accuracy of the data. It should also be noted that $z_{PPC} = 11.5$ at T = now corresponds to an $H_0 = 57.3$ adjusted value for the CBR redshift correction of 11 cited as necessary by the authors in an earlier paper.[(2)]

The data in Table I also give an indication of how the mass–energy conversion process is related to conservation of energy. If no such conversion existed, the blackbody radiator at $T = t_p$ would not exist, and the locally observed redshift relative to T^* would be $z_{PPC} = \ln T/T^*$ with $\rho_m/\rho_r = 0$. Thus $z_G = z_L$ only at $T = T^*$, and the system would only be energy-balanced at its initial state. This suggests that the conversion of radiative energy to mass form is a necessary consequence of requiring the locally observed impact of space-time curvature caused by system dynamic expansion to be energy-balanced globally.

It should be noted that only a subset of the constraints was used to develop (model-dependent) Eq. (19). These included:

(1) conservation of energy globally in the $(\rho_m/\rho_r)^{1/3}$ term;
(2) general relativity via local space curvature represented by the $\ln T/t_p$ term;
(3) Stefan–Boltzmann law for a continuously observable blackbody radiator in the $(\rho_m/\rho_r)^{1/4}$ term.

An equivalence between locally perceived and globally defined CBR redshift was also exploited. The remaining constraints were then invoked in connection with developing the inverse square law-based (model-independent) age expression in Eq. (21).

4. SUMMARY AND CONCLUSIONS

The analysis given here demonstrates the following. Given a closed expanding (4-space) hyperspherical space-time system which

(1) is expanding globally at the constant rate c along its temporal axis,
(2) conserves energy globally in 3-space,
(3) features light cone topology which locally corresponds to flat space-time as $s \to 0$,
(4) has an initial CBR energy state of $\lambda_{CBR} = L^*$ at age $T = T^*$ with $(\rho_m/\rho_r) = 0$,
(5) forms a blackbody radiator at $T = t_p \approx 1.74 \times 10^5$ yr with $H_0 \approx 57.3$ (topology change corrected from a reference locus of $t_p \approx 3.0 \times 10^5$ yr with $H_0 = 50$ in flat space-time),
(6) has locally observed CBR temperature = 2.73 K ($\lambda_{CBR} \approx 1.1 \times 10^{-1}$ cm) at T = now with $\rho_m/\rho_r \approx 10^4$, and
(7) conserves locally observed CBR luminal flux,

then such a system will manifest the following attributes:

(1) system age $T = t_p \exp[(\rho_m/\rho_r)^{1/3} - (\rho_m/\rho_r)^{1/4}]$ for $T \geq t_p$, $\rho_m \geq \rho_r$ with specific solutions:
(a) $\rho_m/\rho_r = 1$ at $T = t_p \approx 1.74 \times 10^5$ yr, and
(b) $\rho_m/\rho_r = 10^4$ at T(now) $\approx 17.2 \times 10^9$ yr;
(2) system age $T = [\lambda_{CBR}/(z + 1)L^*]^2 T^*$, where

$$(z + 1) = (\rho_m/\rho_r)^{1/3} \text{ or } \ln(T/t_p) + (\rho_m/\rho_r)^{1/4}$$

with dual specific solution T(now) $\approx 17.1 \times 10^9$ yr with $\rho_m/\rho_r = 10^4$ and $\lambda_{CBR} \approx 1.1 \times 10^{-1}$ cm (2.73 K);
(3) observed CBR wavelength

$$\lambda_{CBR} = (z + 1)\{\exp[(z + 1) - (z + 1)^{3/4}]\}^{1/2}\lambda_p,$$

where $\lambda_p = (t_p/T^*)^{1/2}L^*$ and $z + 1 = (\rho_m/\rho_r)^{1/3}$ via equivalence of the above age expressions;

(4) locally perceived flat space-time as a result $\rho_m \approx \rho_c$ and asymptotic flatness; and

(5) matter formation as a necessary consequence of requiring local space-time curvature impacts to be energy balanced globally.

Where it is possible to make a comparison, these attributes seem to correlate rather well with observed data regarding stellar cluster age and CBR data obtained recently by the COBE satellite. The results also argue in favor of a (locally perceived) Einstein–de Sitter model of the universe with $\Omega = 1$ and $H \approx 57$. They also indicate that such a flat space-time solution to Eq. (4) evokes a Hubble time which is equal to the age of the expanding hypersphere ($T \approx 17.1 \times 10^9$ yr for $\rho_m \approx \rho_c$ and $H \approx 57.3$). Because of the use of $\rho_m/\rho_r \approx 10^4$, the results are also consistent with current views regarding the existence of dark matter.

The close quantitative agreement of computed values obtained in a three-way cross-check of system age provides additional positive evidence to support the validity of the topological method employed here. The agreement on age also suggests a (surprisingly) close synergism between an observed CBR temperature of 2.73 K and $\rho_m/\rho_r \approx 10^4$ at T = now within the context of the analysis presented. Moreover, if a drag constraint on expansion is imposed, the derived age results can be interpreted as a strict lower bound on the age of the system for the CBR constraint conditions defined at T = now. As indicated in the prior section, the analytical approach used also provides insight regarding the nature of energy balance and conversion processes in an expanding hyperspherical system and their relationship to observed space-time curvature in the local framework. Clearly, the results give a direct answer to the question, which was recently posed by Turner,[21] Why is the temperature of the universe 2.726 K? Any other value of observed CBR would disagree with observed age and the other constraint conditions used in the analysis of age presented here.

It should also be noted that as an alternative to the analysis given here, the absence of gravitational drag in the global model could be interpreted in terms of a nonzero cosmological constant Λ which exactly balances gravitational drag found in the local solution to Eq. (4). One might associate the geometric and dynamic character of the topological model employed here with a "self-gravitating vacuum" process. Such a process was recently suggested by Fukugita, Hogan, and Peebles[22] as a potential basis for improving the standard model. The impact of interpreting the hyperspherical model in such a way would be to force the age of a flat space-time universe to be exactly equal to the Hubble time (instead of 2/3 of it). An age value computed in this way would agree more closely with the age results presented here based upon observed CBR attributes in an expanding hypersphere.

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Résumé

Cet exposé examine les limites par lesquelles un modèle global simple (perspective extérieure) puisse être utile pour caractériser le rayonnement cosmique de l'univers physique. L'espace-temps est présenté comme un système hypersphérique fermé en expansion dynamique. Ce modèle est utilisé comme un moyen d'analyse avec contraintes (en fonction de la température des rayons cosmiques et autres conditions qui sont spécifiques à l'univers physique) pour déterminer l'âge du système. Nous présentons des résultats analytiques pour montrer la consistence mutuelle entre les attributs observés: (1) espace-temps apparemment plat ($\rho_m \approx \rho_c$), (2) la température du rayonnement cosmique à ≈ 2.73 K, et (3) l'âge $\approx 17.2 \times 10^9$ années lorsque ceux-ci sont observés localement par un observateur situé dans le système hyperspérique en expansion. De nombreuses vérifications sont faites pour valider la consistence des résultats. Les contraintes utilisées incluent: (1) la conservation d'énergie, (2) la relativité générale et restreinte, (3) les limites d'observation de la mécanique quantique (T^*, L^*), (4) les résultats observés du rayonnement cosmique (2.73 K température, la dimension apparente de l'univers primordial ($\approx 3 \times 10^5$ années), et le rapport de la masse à la densité de l'énergie de la radiation ($\rho_m/\rho_r \approx 10^4$), et (5) conservation d'observation locale de rayons cosmiques du flux lumineux. Les résultats impliquent que la conversion d'énergie de la radiation à masse est une conséquence d'une exigence que la courbure d'espace-temps localement observée soit d'énergie balancée globalement.

References

1. E.J. Bacinich and T.A. Kriz, "Hubble Expansion-caused Distortion in Cosmological Observations," GR13 Abstracts, International Conference on Gravity & General Relativity, Cordoba, Argentina, 1992.
2. *Idem*, Phys. Essays **8**, 4 (1995).
3. W.A. Fowler, "The Age of the Observable Universe (Argument for a Short Age of 11.0 ± 1.6 Gyr)," 14th Texas Symposium on Relativistic Astrophysics, Ann. N.Y. Acad. Sci. **571**, 68 (1989).
4. J.L. Tonry, "Cosmological Parameters," Texas/PASCOS '92, Ann. N.Y. Acad. Sci. **688**, 113 (1993).
5. A. Renzini, "The Age of the Universe," *ibid.*, p. 124.
6. M. Jones *et al.*, Nature **365**, 320 (1993).
7. J. Huchra, Science **256**, 321 (1992).
8. S. van den Bergh, *ibid.* **258**, 421 (1992).
9. P.J.E. Peebles, *Principles of Physical Cosmology* (Princeton University Press, 1993), p. 139.
10. R. Penrose, "Difficulties with Inflationary Cosmology," 14th Texas Symposium on Relativistic Astrophysics, Ann. N.Y. Acad. Sci. **571**, 249 (1989).
11. K.R. Lang, *Astrophysical Formulae* (Springer–Verlag, Berlin, 1986), p. 602.
12. J.C. Mather *et al.*, "Recent Results from COBE," Proceedings from GR13, International Conference on Gravity & General Relativity, Cordoba, 151, Argentina, 1992.
13. R. Penrose, "Conformal treatment of infinity," in *Relativity, Groups, & Topology*, edited by C. DeWitt and B. DeWitt (Gordon & Breach, NY, 1964).
14. *Idem*, "Structure of Spacetime," in *1967 Lectures in Math. & Physics*, edited by C. DeWitt and J.A. Wheeler, (Benjamin, NY, 1968), p. 565.
15. S.W. Hawking, Mon. Not. R. Astron. Soc. **152**, 75 (1971).
16. *Idem*, Commun. Math. Phys. **25**, 152 (1972).
17. *Idem*, "The Event Horizon," in *Black Holes*, edited by C. DeWitt and B. DeWitt (Gordon & Breach, NY, 1973), p. 1.
18. S.W. Hawking and R. Penrose, Proc. R. Soc. A **314**, 529 (1970).
19. C.W. Misner, Phys. Rev. Lett. **22**, 1071 (1969).
20. A. Guth, Phys. Rev. D **23**, 347 (1981).
21. M.S. Turner, Science **262**, 861 (1993).
22. M. Fukugita, C.J. Hogan, and P.J.E. Peebles, Nature **366**, 309 (1993).

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