5,1 Addendum Chapter 1
Calculation of Cosmic Background Radiation

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1, Introduction

In the year 2000, the author proved that the Yilmaz Cosmology Model predicts a steady-state universe that should exhibit Cosmic Background Radiation having a blackbody temperature that is comparable to the 2.73 Kelvin temperature measured by the COBE satellite. This analysis is presented in Appendix D of *Believe* [1].

The early analysis used a crude approximation. This article gives a rigorous analysis of Cosmic Background Radiation, which extends the analysis in *Believe* [1], to predict Cosmic Background Radiation with a blackbody temperature of 4.0 degrees Kelvin.

Section 2 applies astronomical data to obtain a formula for the Luminosity Density of the Universe. This is applied to the Yilmaz cosmology model to obtain a formula for the photon rate that is received locally at microwave frequencies from the radiation of very distant stars. From this result, Section 3 derives a formula for the spectrum of the Cosmic Background Radiation received from distant stars. Section 4 applies this formula to calculate the spectrum of the Cosmic Background Radiation derived from the Yilmaz cosmology model. Section 5 discusses the results of this analysis.

2, Basic Formula for Photon Rate Intensity

Appendix D of Believe [1] calculates the radiation from very distant stars that has been Doppler shifted to very low frequencies. Equation D-7 of Appendix D gives the following for the intensity of the received light in terms of the photons that are received from stars at a distance (r) that lie within an increment of distance (Δr):

$$N^*_{rec}/A = \tfrac{1}{4} (N^*/v) K_x^2 \Delta r \qquad (1)$$

The quantity (N^*/v) is the average photon rate per unit volume radiated from the distant stars, which the Yilmaz Cosmology Model assumes to be constant throughout the universe. The quantity (N^*_{rec}/A) is the Doppler-shifted intensity of the photon-rate received locally due to the radiation from these distant stars. This intensity of the photon rate represents the received photon rate N^*_{rec} falling on an area A. The parameter K_x represents the reciprocal of the spatial contraction ratio ($\Delta r_{ap}/\Delta r$) predicted by the Yilmaz Cosmology Model. The quantity Δr is a true increment of distance and Δr_{ap} is the apparent distance increment that corresponds to this true distance increment. The parameter K_x is equal to

$$K_x = (\Delta r/\Delta r_{ap}) = \exp[(r/r_o)^2/2] \qquad (2)$$

Substituting Eq. 2 into Eq. 1 gives

$$N^*_{rec}/A \;=\; \tfrac{1}{4}\,(N^*/v)\,\exp[(r/r_o)^2]\;\Delta r \qquad (3)$$

Luminosity Density of the Universe. The quantity (N^*/v) in Eq. 3 is the photon luminosity density of the universe, expressed in terms of the photon rate per unit volume of the universe. Our value for the luminosity density of the universe is based on data given by Narlikar [5] (page 304). Narlikar states that the best astronomical estimate for the luminosity density of the universe comes from the *Revised Shapely Ames Catalogue*, which gives the following values for the luminosity density for different classes of galaxies:

Spiral galaxies: $0.44{*}10^8\ L_{sun}h_o/Mpc^3$ (4)

Elliptical and SO galaxies: $1.74{*}10^8\ L_{sun}h_o/Mpc^3$ (5)

In accordance with Narlikar's directions, these two values should be added to obtain the total luminosity, which is

$$\text{Total Luminosity} \;=\; 2.18{*}10^8\ L_{sun}h_o/Mpc^3 \qquad (6)$$

We assume a Hubble constant of

$$H_o \;=\; 20\ (km/sec)/MLyr \;=\; 65.2\ (km/sec)/Mpc \qquad (7)$$

where MLyr means one million light years, and Mpc means one million parsecs. Dividing the Hubble constant H_0 by 100 (km/sec)/Mpc gives the normalized Hubble constant h_0. From Eq. 7, the normalized Hubble constant is (h_o = 0.652). Substituting this value for h_o into Eq 6, and setting Mpc = 3.26 MLyr, gives

$$\text{Universe Luminosity} \;=\; P/v \;=\; 4.103{*}10^6\ L_{sun}/MLyr^3 \;=\; 4.103{*}10^{-12}\ L_{sun}/Lyr^3 \qquad (8)$$

We have set MLyr = 10^6 Lyr. Equation 8 gives the ratio of power P to the universe volume v. This website shows in *5,A Addendum Appendix A*, Eq. 41, that the photon rate of the sun can be approximated by considering the sun to be an ideal blackbody at a temperature of 5770 °K. This equation gives the following for the sun's photon rate

$$N^*_{sun} \;=\; 1.530{*}10^{45}\ \text{photons/sec} \qquad (9)$$

Substituting N^*_{sun} for the sun luminosity L_{sun} in Eq 8 gives the following for the average luminosity of the universe expressed in terms of photon rate:

$$N^*/v \;=\; 6.278{*}10^{33}\ (\text{photons/sec})/Lyr^3 \qquad (10)$$

This is an approximation. A detailed analysis of astronomical data would be needed to obtain a more accurate estimate of average photon rate radiated per unit volume of the universe. To simplify the calculation, it is convenient to multiply this by $(15{*}10^9\ Lyr)/r_0$, where r_0 is 15 billion light years (Lyr). This gives

$$N^*/v = 9.416*10^{43}/r_0 \text{ (photons/sec)/Lyr}^2 \quad (11)$$

One light-year Lyr is equal to the following distance in centimeters

$$\text{Lyr} = 9.47*10^{12} \text{ km} = 9.47*10^{17} \text{ cm} \quad (12)$$

Applying this to Eq 11 gives

$$N^*/v = 1.050*10^{8}/r_0 \text{ (photons/sec)/cm}^2 \quad (13)$$

Substitute this into Eq. 3, and (for simplicity) drop the (rec) subscript on N*. This gives

$$N^*/A = \tfrac{1}{4} (N^*/v) \exp[(r/r_o)^2] \, \Delta r = (1.050*10^8/4) \exp[(r/r_o)^2] \, (\Delta r/r_0)$$

$$= 2.625*10^7 \, (\Delta r/r_0) \exp[(r/r_o)^2] \quad (14)$$

3, Derivation of Formula for Cosmic Background Radiation

Formula for Photon Rate. In Appendix D of *Believe* [1], Eqs D-32 and D-36 give the following formulas:

$$N^*/A = K_1 \, (\Delta r/r_0) \exp[(r/r_0)^2] \quad (15)$$

$$\text{where } K_1 = 2.625\text{x}10^7 \text{ (photon/sec)/cm}^2 \quad (16)$$

$$(\lambda_{rad}/\lambda) = \tfrac{1}{2} \exp[-(r/r_0)^2/2] \quad (17)$$

The variable N* is the photon rate of the received cosmic background radiation expressed in photons/second, and the ratio N*/A is the photon rate intensity in photons/second per square centimeter of receiver area A. The variable r is the true distance to the stars radiating these photons, and Δr is the increment of true distance over which the stars are located. Parameter r_0 is the radius of the "observable universe" (15 billion light years), which is calculated from the Hubble constant. Parameter λ_{rad} is the wavelength of the light radiated from the distant stars and λ is the wavelength of the resultant Doppler-shifted starlight that is received locally. We denote the frequency of the locally ***received*** starlight as (f). The frequency of the light ***radiated*** by the stars is denoted f_{rad} and also as F. Hence we can set

$$(\lambda_{rad}/\lambda) = f/f_{rad} = f/F \quad (18)$$

Substituting Eq 18 into Eq 17 gives

$$2f/F = \exp[-(r/r_0)^2/2] \quad (19)$$

This can be expressed as

$$(F/2f)^2 = \exp[(r/r_0)^2] \tag{20}$$

Differentiating Eq. 19 gives

$$2\, df/F = -\exp[-(r/r_0)^2/2]\,(r/r_0)\,(dr/r_0) \tag{21}$$

Substituting Eq 19 into Eq 21 gives

$$df/f = -(r/r_0)\,(dr/r_0) \tag{22}$$

Replace df, dr by Δf, Δr, and solve for $\Delta r/r_0$

$$\Delta r/r_0 = -(r_0/r)\,(\Delta f/f) \tag{23}$$

Substitute Eqs 20, 23 into Eq 15.

$$N^*/A = -K_1\,(r_0/r)\,(\Delta f/f)\,(F/2f)^2 \tag{24}$$

The ratio $(\Delta f/f)$ is negative and so $\{-(\Delta f/f)\}$ is positive, and can be replaced by $|\Delta f/f|$, which is the absolute value of $(\Delta f/f)$. Solve Eq 20 for (r/r_0)

$$(r/r_0) = \sqrt{[2 \ln\{F/2f\}]} \tag{25}$$

Substitute this into Eq 24, while replacing $\{-(\Delta f/f)\}$ by $|\Delta f/f|$. This gives

$$N^*/A = \{(K_1/4)\,|\Delta f/f|\,(F/f)^2\}/\sqrt{[2 \ln(F/2f)]} \tag{26}$$

Spectrum of Radiation Received from Distant Stars. Equation 19 shows that for a star at a given distance r, the ratio f/F is constant. We assume that the stellar radiation has a blackbody spectrum. Therefore the spectrum of the received radiation also has a blackbody spectrum, which is displaced in frequency.

To simplify our analysis, we assume that all distant stars have the same blackbody temperature, denoted T_{star} , and so they all have the same spectrum. Although this is a crude approximation, it should be adequate for preliminary analysis. We denote the half-power wavelength and frequency (λ_h and f_h) of the distant star of blackbody temperature T_{star} by the parameters λ_{star} and F_{star} . From *5,A Addendum Appendix A*, Eq 7 shows that $(\lambda_h T)$ is equal to (0.4107 cm-°K). Hence,

$$\lambda_{star} T_{star} = 0.4107 \text{ cm-°K} \tag{27}$$

Since $F = c/\lambda$, we have

$$F_{star} = c/\lambda_{star} = T_{star}\,(c/0.4107)\ (\text{cm-°K})^{-1} \tag{28}$$

For a blackbody, the half-power frequency is proportional to the blackbody temperature. Hence

$$F_{star}/f_h = T_{star}/T \qquad (29)$$

where T is the blackbody temperature of the locally received blackbody radiation, and f_h is the half power frequency of that radiation.

From Eq 1, consider N*/A to be the power P emitted from a blackbody radiator. The spectral density dP/df is then d(N*/A)/df. In Eq. 61 of *5,A Addendum Appendix A*, replacing P with N*/A gives the following spectral density at the half-power frequency f_h

$$d(N^*/A)/df. = (N^*/A)/K_{bb}f_h \qquad \text{at } f = f_h \qquad (30)$$

Applying Eq. 26 gives the spectral density at the half-power frequency f_h :

$$\text{at } f_h: \quad d(N^*/A)/df = \{(K_1/4)\,|\Delta f/f|\,(F_{star}/f_h)^2\}/\{K_{bb}f_h\sqrt{[2\ln(F_{star}/2f_h)]} \qquad (31)$$

In *5,A Addendum Appendix A*, Eq 60 gives the following formula for the general blackbody spectrum expressed in terms of frequency:

$$(dP/df) = \{[dP/df]_h\}K_0(f/f_h)^3/\{[\exp[3.501(f/f_h)] - 1\} \qquad (32)$$

As shown in Eq. 63 of *5,A*, the constant K_0 is [exp(3.501) - 1], and $[dP/df]_h$ is the value of (dP/df) at the frequency f_h. Replacing P by (N*/A) in Eq. 32 gives

$$d\,(N^*/A)/df = \{[d(N^*/A)/df]_h\}K_0(f/f_h)^3/\{[\exp[3.501(f/f_h)] - 1\} \qquad (33)$$

The expression $[d(N^*/A)/df]_h$ is the value of d(N*/A)/df at the frequency f_h, which is given in Eq. 31. Combining Eqs 31 and 33 gives the following for the spectral density at any frequency f (which we denote f_x):

$$d(N^*/A)/df = \{(K_0K_1/4)|\Delta f/f|(F_{star}/f_h)^2(f_x/f_h)^3\}/\{K_{bb}f_h\sqrt{[2\ln(F_{star}/2f_h)]}[\exp(3.501f_x/f_h) - 1]\} \qquad (34)$$

Let us define the relation between the frequencies f_h and f_x as follows:

$$f_h = k^n f_x \qquad \text{where } n = \text{integer} \qquad (35)$$

Applying Eq. 35 to Eq. 34 gives

$$d(N^*/A)/df = \{(K_0K_1/4)|\Delta f/f|k^{-2n}(F_{star}/f_x)^2k^{-3n}\}/\{K_{bb}k^nf_x\sqrt{[2\ln(F_{star}/2f_x\,k^n)]}[\exp(3.501k^{-n}) - 1]\} \qquad (36)$$

This simplifies to

$$d(N^*/A)/df = \{(K_0K_1/4)|\Delta f/f|(F_{star}/f_x)^2k^{-6n}\}/\{K_{bb}f_x\sqrt{[2\ln((F_{star}/2f_x)\,k^{-n})]}[\exp(3.501k^{-n}) - 1]\} \qquad (37)$$

The square root in the denominator can be expressed as

$$\sqrt{[2\ln((F_{star}/2f_x)k^{-n})]} = \sqrt{[2\{\ln(F_{star}/2f_x) - n\ln(k)\}]} = \sqrt{[2\ln(F_{star}/2f_x)]}\sqrt{[1- 2\delta]} \quad (38)$$

where δ is equal to

$$\delta = \{ n \ln(k^{\backslash})\}/\{2 \ln(F_{star}/2f_x)\} \quad (39)$$

The absolute value of the quantity (2δ) is much less than unity, and so $\sqrt{[1- 2\delta]}$ can be closely approximated by

$$\sqrt{[1- 2\delta]} \approx [1- \delta] \approx 1/(1+\delta) \quad (40)$$

Applying this approximation to Eqs. 37, 38 gives

$$d(N^*/A)/df = \{(K_0K_1/4)|\Delta f/f|(F_{star}/f_x)^2k^{-6n}(1+\delta)\}/\{K_{bb}f_x\sqrt{[2\ln(F_{star}/2f_x)]}[\exp(3.501k^{-n}) - 1]\} \quad (41)$$

Equation 41 can be expressed as

$$d(N^*/A)/df = H_1 H_2 \quad (42)$$

Where the functions H_1 , H_2 are defined as

$$H_1 = \{(K_1/4)(F_{star}/f_x)^2\}/\{K_{bb}f_x\sqrt{[2\ln(F_{star}/2f_x)]}\} \quad (43)$$

$$H_2 = \{K_0 |\Delta f/f| (1 + \delta) k^{-6n}\}/[\exp(3.501k^{-n}) - 1]\} \quad (44)$$

The quantity $(1 + \delta)$ in Eq. 44 is only a weak function of the ratio (F_{star}/f_x), and so the function H_2 is a weak function of the (F_{star}/f_x) ratio. The function H_1 is not a function of the integer n.

Total Blackbody Spectrum Received From Distant Stars. Equations 41 to 44 specify the spectral density at a particular frequency f_x of radiation received from stars at a distance r over an increment of distance Δr. In this model we assume that all of the distant stars are blackbody radiators having the same blackbody temperature T_{star} and hence the same half-power frequency F_{star} . By Eq. 23, the increment of distance Δr is specified by

$$|\Delta r/r_0| = (r_0/r) |\Delta f/f| \quad (45)$$

The radiation received from stars that lie within the distance interval Δr has blackbody spectra with half-power frequencies that vary over the range Δf. If the resultant $|\Delta f/f|$ ratio (as specified by Eq. 29) is much less than unity, we can consider that all of these spectra have the same half-power frequency f_h Hence Eqs. 41 to 44 give the spectral density at the frequency f_x of all of the radiation received from stars that lie within the distance interval Δr. To obtain the total spectral density at the frequency f_x , we sum the d(N*/A)/df expression of Eq. 41 over all values (positive and negative) of the integer n. This gives:

$$\text{Total}\{d(N^*/A)/df\} = H_1 \Sigma_n H_2 \quad (46)$$

The relative frequency interval $|\Delta f/f|$ and the parameter k defined by Eq. 35 are related by

$$|\Delta f/f| = (1 - k)(1 + k)/2k \qquad (47)$$

By this relation, the parameters k and $|\Delta f/f|$ set the complete frequency interval of the received radiation. As k approaches unity, this gives an exact result. We choose k = 0.9 to achieve a good approximation. Thus, we assume

$$k = 0.9 \ ; |\Delta f/f| = 0.10556 \qquad (48)$$

By Eq. 44, the expression $\Sigma_n H_2$ in Eq. 46 can be expressed as

$$\Sigma_n H_2 = |\Delta f/f| \Sigma_n (1 + \delta) k^{-6n} \{[\exp(3.501) - 1]/[\exp(3.501k^{-n}) - 1] \qquad (49)$$

The constant K_0 was replaced by [exp(3.501) - 1]. By Eq. 39, δ is equal to

$$\delta = \{ n \ln(k^-)\}/\{2 \ln(F_{star}/2f_x)\} \qquad (50)$$

Let us consider a single blackbody spectrum that has (at its half-power frequency) the spectral density d(N*/A)/df that is computed from the above equations. We can regard the power of this spectrum as representing the photon rate intensity (N*/A) that corresponds to the computed spectral density d(N*/A)/df. From *5,A Addendum Appendix A*, Eq 61 gives

$$[dP/df] \text{ at } f_h = P/K_{bb}f_h \qquad (51)$$

Solving Eq. 61 of *5,A* for P gives

$$P = K_{bb}f_h[dP/df] \qquad (52)$$

Setting (P) equal to (N*/A) gives (from 46)

$$N^*/A = K_{bb}f_x [d(N^*/A)/df] = K_{bb}f_x H_1 \Sigma_n H_2 = H_3 \Sigma_n H_2 \qquad (53)$$

where H_3 is defined as

$$H_3 = K_{bb}f_x H_1 = \{(K_1/4)(F_{star}/f_x)^2\}/\{\sqrt{[2\ln(F_{star}/2f_x)]}\} \qquad (54)$$

Final Equations. The ratio (F_{star}/f_x) is equal to (T_{star}/T), where T is the blackbody temperature of the locally received radiation. Hence Eqs. 54, 50 can be expressed as

$$H_3 = (K_1/4)(T_{star}/T)^2/\sqrt{[2\ln(T_{star}/2T)]} \qquad (55)$$

$$\delta = n \ln(k^-)/2 \ln(T_{star}/2T) \qquad (56)$$

Combining Eqs 49, 53 gives

$$N^*/A = H_3 \Sigma_n H_2 = H_3 |\Delta f/f| \Sigma_n (1 + \delta) k^{-6n} \{[\exp(3.501) - 1]/[\exp(3.501k^{-n}) - 1] \quad (57)$$

By Eq. 15, the constant K_1 in Eq. 55 is equal to

$$K_1 = 2.625x10^7 \ \ (\text{photon/sec})/\text{cm}^2 \quad (58)$$

To simplify computation, it is convenient to define, from Eq. 50, the following function W(n):

$$W(n) = (1 + \delta) k^{-6n} \{[\exp(3.501) - 1]/[\exp(3.501k^{-n}) - 1] \quad (59)$$

In terms of this function, Eq 57 becomes

$$N^*/A = H_3 |\Delta f/f| \Sigma_n W(n) \quad (60)$$

4, Computation of Blackbody Radiation

Let us assume that the distant stars all have blackbody spectra with the blackbody temperature of the sun, which is

$$T_{star} = T_{sun} = 5770 \text{ °K} \quad (61)$$

We will see that the analysis will yield a blackbody temperature T of about 4 °K. Hence we will assume this as the value for T in the calculation of δ from Eq. 56. The expression (1 + δ) is a weak function of T, and so a wide variation of the value of T in computing δ will not appreciably alter the final result. As stated in Eq. 48, we set k = 0.9. From Eq. 56, the value for δ is

$$\delta = n \ln(k)/2 \ln(T_{star}/2T) = n \ln(0.9)/2 \ln[5770/2(4)] = - 8.005{*}10^{-3} n \quad (62)$$

Applying this to Eq 59 gives

$$W(n) = (1 + 0.00801 n) k^{-6n} \{[\exp(3.501) - 1]/[\exp(3.501k^{-n}) - 1] \quad (63)$$

Setting k = 0.9, Eq. 5-70 yields the following values of W(n) for the positive and negative vales of the integer n that yield significant W(n) values:

W(1) = 1.273	W(2) =1.555	W(3) = 1.818	W(4) = 2.012
W(5) = 2.105	W(6) = 2.062	W(7) =1.879	W(8) = 1.579
W(9) = 1.213	W(10) = 0.842	W(11) = 0.523	W(12) = 0.287
W(13) = 0.137	W(14) = 0.056	W(15) = 0.019	W(16) = 0.003
W(0) = 1	W(-1) = 0.758	W(-2) = 0.557	W(-3) = 0.398

W(-4) = 0.278 W(-5) = 0.190 W(-6) = 0.127 W(-7) = 0.084

W(-8) = 0.054 W(-9) = 0.035 W(-10) = 0.022 W(-11) = 0.014

W(-12) = 0.008 W(-13) = 0.004

The sum of the above values of W(n) is

$$\Sigma_n W(n): = 20.892 \tag{64}$$

By Eq. 48, $|\Delta f/f|$ is equal to 0.10556, and so $\Sigma_n H_2$ is equal to

$$\Sigma_n H_2 = |\Delta f/f| \Sigma_n W(n): = (0.10556)(20.892) = 2.205 \tag{65}$$

By Eqs 57, 55, the photon-rate intensity is equal to

$$N^*/A = H_3 \Sigma_n H_2 = 2.205 H_3 = 2.205(K_1/4)(T_{star}/T)^2/\surd[2\ln(T_{star}/2T)] \tag{66}$$

Applying the value of K_1 in Eq. 58 gives

$$N^*/A = 1.023{*}10^7 (T_{star}/T)^2/\surd[\ln(T_{star}/2T)] \text{ (photon/sec)/cm}^2 \tag{67}$$

This is the photon rate intensity of cosmic background radiation received from the radiation of far distant stars.

Computation of Cosmic Background Blackbody Temperature. gives in Appendix A, Eq. 46 in *5,A Addendum Appendix A* , gives the following formula for the photon-rate intensity that is radiated from an ideal blackbody:

$$N^*/A = 1.306{*}10^{11} T^3 \text{ (photon/sec)/(cm}^2\text{-°K}^3) \tag{68}$$

The radiation from an ideal blackbody is in thermal equilibrium with molecules at the surface. We postulate that this intensity level cannot be exceeded by cosmic radiation. Otherwise the diffuse matter in space would rapidly absorb the cosmic radiation. Setting Eq. 68 equal to Eq. 67 gives

$$T^3 = \{(1.023{*}10^7)/(1.306{*}10^{11})\}(T_{star}/T)^2/\surd[\ln(T_{star}/2T)] \text{ (°K}^3) \tag{69}$$

This can be expressed as

$$T^5 = 7.833{*}10^{-5} (T_{star})^2/\surd[\ln(T_{star}/2T)] \text{ (°K}^3) \tag{70}$$

We assume that $T_{star} = T_{sun}$ = 5770 °K. This gives

$$T^5 = 2..608{*}10^3/\surd[\ln\{(5770 \text{ °K})/2T)\}] \text{ (°K}^5) \tag{71}$$

This can be solved by trial and error, setting T initially equal to 4 °K. The final value for T is

$$T = 3.994 \text{ °K} \quad (72)$$

Hence this model predicts a blackbody temperature of 3.99 °K for Cosmic Background Radiation. The true value measured by the COBE satellite was 2.73 °K. Our calculated blackbody temperature exceeds the true value by 46 percent.

In Eqs 67, 68, set T = 2.73 °K and set $T_{star} = T_{sun} = 5770$ °K. This gives

Stellar Radiation: $N^*/A = 17.32 * 10^{12}.$ (photon/sec)/cm^2 (73)

Ideal Blackbody: $N^*/A = 2.657 * 10^{12}$ (photon/sec)/cm^2 (74)

At the blackbody temperature (2.73 °K) of Cosmic Background Radiation, our calculated stellar radiation from distant stars exceeds the radiation from an ideal blackbody by the ratio 17.32/2.657, which is 6.52. Equation 25 gives the following for the relative distance (r/r_0) of the stars that generate the Cosmic Background Radiation:

$$(r/r_0) = \sqrt{[2 \ln\{F/2f)]} = \sqrt{[2 \ln\{T_{star}/2T)]} \quad (75)$$

If we assume that $T_{star} = T_{sun} = 5770$ °K, and T = 2.73 °K, the ratio (r/r_0) is 3.732. Since r_0 is 15 billion light years, the distance r is 56.0 billion light years.

5, Discussion

Thus, our analysis of the Yilmaz Cosmology Model predicts Cosmic Microwave Radiation with a blackbody spectrum having a blackbody temperature of 3.99 degree Kelvin, which is 46 percent greater than the 2.73 degree Kelvin measurement obtained from the COBE satellite. This radiation comes from stars located at a distance of 56 billion light years. This 46 percent discrepancy in blackbody temperature is equivalent to a factor of 6.52 loss in light energy, which corresponds to a signal attenuation of about 8 decibels and is equivalent to a 2.0 increase in stellar magnitude.

When one considers the many possible causes of error in this analysis, an 8 decibel discrepancy is quite reasonable. A major weakness of the analysis is that it assumes that all stars have the same light spectrum, which is the spectrum of our sun. Another problem is that the analysis is based on an estimate of the average luminosity of the universe, which is subject to appreciable error.

References

[1] Adrian Bjornson, *A Universe that We Can Believe*, Addison Press, 2000, ISBN 09703231-0-7 (Appendix D)..
[5] J.V. Narlikar, *Introduction to Cosmology*, 1993, 2nd Ed., Cambridge University Press, ISBN 0-521-42352-X.