Single parameter model for cosmic scale photon redshift in a closed Universe

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Abstract

A successful single parameter model has been formulated to match the observations of photons from type 1a supernovae which were previously used to corroborate the standard Λ cold dark matter model. The new single parameter model extrapolates all the way back to the cosmic background radiation (CMB) without requiring a separate model to describe inflation of the space dimensions after the Big Bang.

The model for the redshift progression of a photon is:

$$1+z = \frac{\sin\left(\frac{13.8}{T}\right)\pi/2}{\sin\left(\frac{t}{T}\right)\pi/2}$$

T is the fitted parameter and t is the time when the photon was emitted, both measured in billions of years from time zero in the Big Bang. The angle is expressed in radians. The number 13.8 should be updated if an improved estimate for the time elapsed since the Big Bang is found.

The single parameter model assumes that spacetime forms a finite symmetrical manifold with positive curvature.

Introduction

An interpretation of the Planck Legacy 2018 release (by Di Valentino, Melchiorri and Silk[1]) concluded that spacetime has a positive curvature at more than the 99% confidence level. Positive curvature implies that the spacetime manifold is finite.

Prior to this discovery, the calculation of the expansion of space assumed that spacetime is flat but expanding with time.

When photons are detected from very distant sources, a calculation is necessary which considers the expansion of space with time. As a result, it is necessary to assume the rate of expansion of space in order to calculate the distance travelled by the photon from the source to the detector. The intensity of the detected photon is related to the light path of the photon and it is the light path distance that is measured. This measurement, using photon intensity, must be corrected to account for the density of matter, referred to as cosmic dust, along the light path.

To date, the usual approach to locating the distance for a far-away galaxy assumes that the expansion of space is related to the increase of the wavelength of the photon. A complicated technique is required to calculate a distance travelled through the expanding space dimension. The calculated progression of the space dimensions is then fitted to a modified Friedmann equation into which at least three parameters are added, and the values of these parameters are regressed to get a good fit. The three added parameters are the cosmological constant, Λ and the quantities referred to as "dark matter" and "dark energy". This approach was pioneered by Peebles[2,3].

Results and Discussion

The complicated regression approach, used with the standard Λ cold dark matter model, can be changed to a single parameter regression approach for a finite and symmetrical spacetime manifold. Rather than using Euclidean geometry, as for the current standard approach, it is now proposed that it is more appropriate to use spherical geometry when the Universe has positive curvature. The calculations are analogous to determining the change in latitude on the surface of the Earth for a known distance over the surface of the Earth and a known ratio of the of latitude and longitude changes.

Using the assumption that the spacetime manifold has a single radius, R which is equal for all three space dimensions and for the time dimension (when the space dimensions are measured in years and the time dimension is measured in light years) leads to a single parameter model to describe the expansion of space with time from the Big Bang event. This expansion of space causes the wavelength of photons to increase in direct proportion with the expansion (when ignoring any potential gravitational redshift or relative motion effects). The spherical geometry is used to locate the time at which the measured photon is emitted.

The space dimension will reach a maximum at time T. If the time elapsed from the Big Bang, t, is expressed as the ratio t/T then this ratio can be multiplied by π/2 to get a change in angle, θ in radians. This is analogous to a change in latitude except that the proposed convention is to measure the angle from a time zero starting point which is at a position analogous to a pole on a globe. The determination of time zero, at a pole, may be a purely theoretical extrapolation since there is no way to observe what happens prior to the release of the first free photons. The measured redshift corresponding to a photon emitted at time t_1 and detected at time t_2 is then determined by the equation:

$1+z = \sin\theta_2/\sin\theta_1$

Assuming that our photon detector near Earth is located at about 13.8 billion light years after the Big Bang then the general formula is:

$$1+z = \frac{\sin\left(\frac{13.8}{T}\right)\pi/2}{\sin\left(\frac{t}{T}\right)\pi/2},$$

where t is the time after the Big Bang time zero when the photon was emitted.

As an illustration, let's assume that a cosmic background radiation (CMB) photon was emitted at about 7.15 million years after time zero, then the redshift for this photon will be given by:

$$1+z = \frac{\sin\left(\frac{13.8}{T}\right)\pi/2}{\sin\left(\frac{0.00715}{T}\right)\pi/2}$$

When T=24, then 1+z = 1089 which agrees with our observations. If the estimate for the current age of the Universe or the time at which the first photons are produced is changed then a new value for T can be found to match the observed redshift.

The highest-known redshift radio galaxy (TGSS J1530+1049)[5] is at 1+z = 6.72. For this galaxy:

$\sin(13.8/24)\pi/2 = 0.785389$, so $\sin(t/24)\pi/2 = 0.785389/6.72 = 0.116873$ which gives t = 1.79 billion years after the Big Bang which is about 12 billion years ago.

So far, the contribution from gravitational redshift has been ignored. This may be reasonable when the spacing between the source and detector is very large. It is assumed, in the following discussion, that the reported cosmological scale factor data has been appropriately interpreted to account for any gravitational redshift effects.

Relative motion for our point of observation has also been ignored. Comprehensive surveys of type 1a supernovae redshift data have recently allowed for correction of this effect[4].

The time t is generally not known for the detected photon since what is measured is the length of the light path travelled by the photon, L.

For a photon, the change in latitude angle is always equal to the change in longitude angle since the units of time and space have been set to make this true for the stated assumptions. The radius of the spacetime manifold, R is related to T by the formula:

$R = 2T/\pi$

If T is set to 2.4×10^{10} years then $2\pi R = (360/90) \times 2.4 \times 10^{10}$ so $R = (4.8 \times 10^{10})/\pi$

L is determined by the equations:

$L = R \sin^{-1}((d/2R^2)(4R^2 - d^2)^{1/2})$ and

$d = R(2 - 2\cos\theta_1\cos\theta_2\cos(\theta_2 - \theta_1) - 2\sin\theta_1\sin\theta_2)^{1/2}$

What has been found is that photons emitted from galaxies which are dated using the standard Λ cold dark matter model approach have red shift values which are very similar to the values calculated as described above for a Universe with positive curvature. This is most likely because the additional fitting parameters have transformed the data from the true spherical basis to a flat basis in much the same way that maps are transformed to flat paper representations of the curved surface of the Earth.

Ringermacher and Mead[6] have provided a useful plot of the cosmological scale factor, $a(t) = 1/(1+z)$ as a function of lookback time.

For $a(t) = 0.5$ which corresponds to $1+z = 2.0$, they report a value of $t = 0.432 \times 13.8 = 5.96$ billion years.

Using this reported value for t, the single fitted parameter model prediction for 1+z is as follows:

$$1+z = \frac{\sin\left(\frac{13.8}{24}\right)\pi/2}{\sin\left(\frac{5.96}{24}\right)\pi/2} = 2.065$$

Although this is not an exact match, it is well within the data scatter in Figure 2 from Ringermacher and Mead[6].

For a lookback time of $0.6 \times 13.8 = 8.28$ billion years the calculation gives:

$1+z = \frac{\sin\left(\frac{13.8}{24}\right)\pi/2}{\sin\left(\frac{8.28}{24}\right)\pi/2} = 1.522526$, so $a(t) = 0.657$ and this is also well within the reported data scatter.

In general, for the data range provided by type 1a supernovae, the fits for the new single fit parameter model and the standard Λ cold dark matter model are both within the data scatter.

Big implications

According to the scientific method, a model fit with fewer parameters is always preferred. So the new single parameter model represents an improved representation of reality. This preferred aproach does not require the unsubstantiated concepts of “dark energy”, “dark matter”, or a cosmological constant insertion into the Friedmann equation. Furthermore, this single parameter model extrapolates all the way back to the CMB radiation without resorting to the use of a separate model which was previously necessary to account for the initial rapid inflation of the space dimension. The success of this model implies that spacetime forms a finite symmetrical manifold.

No doubt, some refinements to the fitted parameter will be necessary to improve the fit as data are accumulated and reworked with improved corrections for gravitational redshift, relative motion, and matter density along the photon pathway.

References

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