In a Self-Consistent Energy-Conserving Universe Dark Energy is the Missing CBR Energy

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Abstract

There are major problems plaguing the standard cosmology model; the most important being the nature and source of the so-called Dark Energy. We prove that the Missing CBR Energy due to matter-dominated expansion has the same present magnitude as Dark Energy. Using the known red-shift when expansion deceleration changes to acceleration, we prove that the scale-factor dependence of Dark Energy is identical to that of the Missing CBR Energy. As well, the change in time of this Missing CBR Energy/Dark Energy explains the discrepancy between the measurements of the Hubble Constant for the present and past Universe expansion. By equating these energies, the fundamental law of conservation of energy is thus obeyed resulting in a self-consistent Universe.

Introduction

Ever since expansion was first observed and measured using the redshift of light, a pervasive paradox has persisted. As Hubble (1936) first noted: *" Obviously, since the product (Energy * Wavelength) = (Planck's Constant * c) remains constant, redshifts, by increasing wavelengths, must reduce the energy in the quanta. Any plausible interpretations of redshifts must account for the loss of energy".*

The majority of photon energy in the Universe is in the CBR, black-body radiation which, since the time of recombination, has undergone redshifts due to expansion of the Scale-Factor a(t). Peebles (1993) comments*:" since the volume of the universe varies as $a(t)^3$, the net radiation energy in a closed universe decreases as $1/a(t)$ as the universe expands. Where does the Missing Energy go?"* The only way cosmologists have explained this apparent non-conservation is by claiming that the universe does not obey its own fundamental law. Peebles (1993) admits: *" .. there is not a general global energy conservation law in general relativity theory."*

Based on Peeble's comments we can expect the Missing CBR Energy to be inversely dependent on the Scale-Factor. By proving this Missing CBR Energy is the so-called Dark Energy, we obtain a self-consistent universe, which does obey its own most fundamental law, the conservation of energy.

Missing Radiation Energy

The recombination epoch begins at around 18,000 years, as electrons are combining with helium nuclei to form He+. At around 47,000 years, as the universe cools, its behavior begins to be dominated by matter rather than radiation. Neutral helium nuclei started to form at around 100,000 years, with neutral hydrogen formation peaking around 260,000 years. This process is known as recombination. The universe thus becomes increasingly transparent to visible light, radio waves and other electromagnetic radiation during this recombination epoch. The post-recombination era is considered to begin at a red-shift of about 1100 and occurs when matter and radiation become totally transparent at about 4000K which results in the observed CBR.

In this present era, conservation of the CBR photons is assumed whose total number was N_p . If each average photon had an energy E_d at the decoupling time, then, as the scale factor R increases, the expansion red-shift causes this energy to be decreased inversely with R.

Assuming a present universe volume of $15*10^9$ ly radius and a present photon density of about 410 photons-cm^{-3} , we obtain the total number of CBR photons Np. Black-body radiation at 2.7K has an average photon energy (E_d/R) of about 10^{-15} erg and at 3000k a photon energy E_d of about $1.13 *10^{-12}$ erg. Thus the total Missing Radiation Energy during the matter-dominated era is about $5.7*10^{75}$ erg. This is about 3 times the total gravitating mass of the universe, assumed to be about 10^{20} solar masses. This ratio is close to that of the observed ratio of 0.68/0.32 of Dark Energy to total mass energy. Given the large uncertainty in the estimates of the volume and mass of the Universe, this result indicates the equivalence in magnitude of Dark Energy with the Missing CBR Energy.

Governing Equations of Universe Expansion

The FLRW equations governing the expansion of the scale-factor R(t) of the Universe are:

(1) $$R_t^2 = 8\pi G/3.\rho R^2 + \Lambda/3.R^2 - k$$

where G is the Gravitational Constant, ρ is the total energy/matter density of the Universe, Λ is a cosmological constant term and k=0,1 or -1 where no imposition of either a flat, closed or open Universe is assumed. The second fundamental equation for this standard model governs the acceleration of the scale-factor:

(2) $$R_{tt} = -4\pi G/3.(\rho+3P)R + \Lambda/3.R$$

where P is the pressure. This approach takes Λ=0 and uses the Standard Model of Universe expansion which invokes Dark Energy with Dark Matter and Baryon Matter. Differentiating (1), which removes any effect of the k term, dividing by R_t and equating with acceleration in (2), yields the equation relating pressure to density, its gradient and Universe expansion:

(3) $$P = -\rho - \rho_t.(R/3R_t)$$

The acceleration is obtained by substituting pressure P from equation (3) into (2), i.e.

(4) $R_{tt} = 4\pi G/3.(2\rho + R\rho_t /R_t).R$

Deceleration Changing to Acceleration

There is only one location in the expansion of the universe that allows an unique determination of the dependence of Dark Energy on the increasing Scale-Factor. Determination of the change in the velocity of expansion by different observational measurements has shown a change from deceleration to acceleration at the red-shift 0.46 yielding a Scale-Factor of 1/1.46 for this unique location.

The standard model of the present Universe has 3 main components namely Baryon Matter of density ρ_b and zero pressure as baryon matter has density proportional to R^{-3}; Dark Matter of density ρ_d and pressure P_d and Dark Energy of density ρ_e and pressure P_e . Substitutions into (4) yields:

(5) $R_{tt} /R = 4\pi G/3.(2\rho_d + d\rho_d/dt .R/R_t + 2\rho_e + d\rho_e/dt .R/R_t - \rho_b)$

When deceleration changes to acceleration in the expansion of the Universe, $R_{tt} = 0$, and so, substituting into (5) gives at this unique location:

(6) $2\rho_d + d\rho_d/dt .R/R_t + 2\rho_e + d\rho_e/dt .R/R_t - \rho_b = 0$

This time has been estimated by Riess et al. (2004) to be at Z=0.46 which gives a relative Scale Factor of then to now of 1.46. The present measured values of these densities are, in relative terms of the critical energy density, $\rho_d = 0.27$, $\rho_e = 0.68$, $\rho_b = 0.05$.

First, examine the Standard Model to see if it is consistent with equation (6); wherein Dark Matter is considered to be mass conserved with zero pressure and Dark Energy to have a constant density. Then L.H.S. Of (6) becomes: $(2\rho_e - \rho_d - \rho_b)$ which at Z=0.46 is equal to : $2(0.68) - (0.27)(1.46)^3 - (0.05)(1.46)^3$ which has the value 0.36 and so such a model is inconsistent with the observed change-over time of Z=0.46.

Next, allow the Dark Matter component to be power-law dependent on the Scale Factor, $\rho_d = 0.27\ R^n$ where we wish to determine the power n. Thus, at the time of change-over from deceleration to acceleration, equation (6) gives: $(2 + n)(0.27)/(1.46)^n = -2(0.68) + (0.05)(1.46)^3 = -1.20$. Iterating to find the value of n yields the approximate solution n = - 3.3. This power dependence on the Scale Factor does not appear to be feasible as it implies loss of Dark Matter as the Universe expands, which is invalid with respect to recent observations of early galaxies, Genzel et al. (2017).

More probably, keeping conservation of Dark Matter and Baryon Matter, allow the Dark Energy to have a power law dependence, $\rho_e = 0.68\ R^m$ where we wish to determine the power m. Thus, at the time of change-over from deceleration to acceleration, equation (6) gives: $(2 + m)(0.68)/(1.46)^m = (0.27)(1.46)^3 + (0.05)(1.46)^3 = 0.99$. Iterating to find the value of m yields the almost exact solution m = -1. This inverse power dependence on Scale-Factor $\rho_e = 0.68\ /R$ is exactly that of the Missing CBR Energy.

Variation in Hubble Constant Measurements

The velocity equation (1) reduces to

$$(7) \qquad R_t^2 / R^2 = 8\pi G/3.\rho = H(R)^2$$

The figure astronomers derive for the present value of the Hubble Constant H(R) using a wide variety of cutting-edge observations to gauge distances across the cosmos is 73.5 km/s/Mpc, with an uncertainty of only two percent. Alternatively, the Hubble Constant can also be estimated from the cosmological model that fits observations of the cosmic microwave background, which represents the young Universe at about the time of re-ionization. When applied to Planck data, this method gives a lower value of 67.4 km/s/Mpc, with a tiny uncertainty of less than a percent, Planck Collaboration (2015).

Riess has outlined a few possible explanations for the mismatch, one being the possibility that Dark Energy, already known to be accelerating the cosmos, may be shoving galaxies away from each other with even greater – or growing – strength. This means that the acceleration itself might have been weaker in the early universe as expected if produced by the Missing CBR Energy which increases as time increases.

From (7) we have :

$$(8) \qquad H(R)^2 = 8\pi G/3 \, [\, \rho_e /R + \rho_d /R^3 + \rho_b /R^3 \,]$$

where we take the density values at the start of the CBR usually taken as redshift Z=1100 and where we nominally put R=1. For a measurement of Hubble Constant at the Scale Factor (R-r) we have :

$$(9) \qquad H(R\text{-}r)^2 = 8\pi G/3 \, [\, \rho_e /(R\text{-}r) + \rho_d /(R\text{-}r)^3 + \rho_b /(R\text{-}r)^3 \,]$$

We can expect, for r small compared to R, that the relative difference between these squared Hubble Constants will be of the order of (r/R) so that the relative difference between the Hubble Constants will be approximately of order $(r/R)^{1/2}$.

From the observational results documented above, the relative difference between the two measurements of the Hubble Constant is about 10% so we would expect for that case that (r/R) would be of the order of 1/100. Using an R = 1100 for the relative Scale-Factor increase since the start of the CBR yields a value for r = 11. The Planck Collaboration (2015) calculated that the CBR measurement occurred at a red-shift of about 8.8. This close agreement gives added credibility to Dark Energy being the Missing CBR Energy.

Conclusion

We have shown that the Missing CBR Energy has similar magnitude and inverse dependence on the Scale-Factor as that of Dark Energy and also explains the increase in time of the measured Hubble Constant. Most gratifying, and with a great sigh of relief, this equivalence confirms that we live in a self-consistent Universe which obeys its own fundamental law, the conservation of energy.

References

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