JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Complete Solution to the Hubble tension from Cosmic Microwave Background Radiation Temperature

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Abstract:

This paper presents a complete solution to the current issue of Hubble tension that arises between Planck 2018 team and SHOES team. Herein we introduce a new constant named as "Dark Constant." Dark Constant is the ratio of X-Energy with the energy of Cosmic Microwave Background Radiation. While estimating X-Energy, we also show the relationship between X-Energy and Hubble's constant (H_o). In the same way we show relationship between Hubble's constant (H_o) and Cosmic Microwave Background Temperature (T). There by we derive a solution to the Hubble tension/issue, estimate the value for Dark Constant, and an estimate for the total age of the universe. This paper estimates the Temperature (T) when age of the universe was 1 second. The main finding of this paper is that the Hubble's constant (H_o) is proportional to the Cosmic Microwave Background temperature and according to this research the correct value for H_o at 2.725K is 72.4646989313493 Km/s/Mpc. Thereby this research resolves the tension arising due to the differing values for H_o presented by the various team.

Keywords:

Hubble constant, Hubble tension, CMB, CMB-Temperature, age of the universe, intergalactic, Dark Constant, Cosmic ladder.

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1. **Introduction:**

In 1908, H.S Leavitt's discovery gave the relationship between period and Luminosity which was used to calculate the Cosmic distances from the earth to stars depending upon their brightness [1]. In 1917, Slipher had calculated the radial velocities of 25 "Spiral nebulae", out of which three are moving away, thus underlining the concept of the expansion of the universe [2]. Big – Bang theory with the expansion of the universe [3]. Edwin Hubble and Georges Lemaitre gave birth to the Hubble – Lemaitre law [4]. Calculating the present value of Hubble parameter H_o by the relation between the radial velocity of galaxies and their distances [5]. Value of H_o obtained from the planck 2018 of $\wedge$CDM model is 67.04 $\pm$ 0.5 km/s/Mpc [6], and according to the SHOES team value is 73.04 $\pm$ 1.04 km/s/Mpc [7]. The value of H_o obtained from the above said teams shows discrepancy known as Hubble tension which still exists. Inhomogeneity concept of the universe with the distribution of galaxies and cosmic structure which are not uniform and also with some differences in the density of matter [8]. Early Dark Energy (EDE) models which was used to study the early expansion of the universe. [9]. Modified gravity as a F(R) gravity [10, 11]. Phantom energy as a dark energy with "W < -1" and Relativistic Degree of Freedom [12]. Vacuum energy as a dark energy which interacts with matter and radiation [13]. Estimating the value of H_o by using the black holes shadow through observation and Cosmic distance estimation [14]. Estimating the value of H_o through statistical method by Grey sirens [15]. Ellipsodial Geometry with anisotropy universe and not a isotropy in the FLRW model [16]. To resolve the Hubble tension by using quantum gravity [17]. Solving the Hubble tension from CMB temperature extraction method with H_o = 66.8713 km/s/Mpc and H_o = 66.8945 km/s/Mpc [23] are the papers regarding resolving the Hubble tension. But Hubble tension still exists and there is no clear or correct solution to this present issue.

In our worksheet we demonstrate that using the respective value of Ho from Planck 2018 - team and SHOES-team and calculating the CMB temperature (T) for each of these methods not only vary among themselves but also differ largely from the present CMB temperature of 2.725K. In our method we derive a relationship between Hubble's constant H_o and CMB temperature (T) by first finding the ratio between X-Energy and CMB Energy. We have named this ratio as "Dark Constant" and using this ratio we establish the relationship between X-Energy and CMB (T) as well as the relationship between X-Energy and H_o. Using all these relationships we derive the correct value for H_o and its associated CMB (T), which matches the present CMB temperature of 2.725K. The value of Planck's constant (h) used in our calculations is 6.62607015x10^{-34}Js[21]. We now proceed to provide the proofs with mathematical equations and examples in the following sections of this paper.

2. Dark Constant(DC):

Since the CMB is a perfect black body radiation and its energy radiation can be calculated by the Planck's famous formula

$$E = h\,v \qquad (1)$$

Now the above equation (1) can be written as follows,

$$E_{Cmb} = hv_{cmb} \qquad (2)$$

Where E_{cmb} is the energy of the CMB radiation in joule, h is the Planck's constant and v is the peak frequency of CMB radiation in Hz or s^{-1}

Now the ratio of the X-Energy with the Energy of the CMB radiation is called as the Dark Constant. This Constant is the dimensionless Constant. This can be expressed in the equation as,

$$\frac{\text{X-Energy}}{\text{CMB-Energy}} = \frac{Ex}{E_{cmb}} = \text{Dark Constant(DC)} \qquad (3)$$

Value of Dark Constant,(DC) is 1.46594448887768 $x10^{-29}$

In the same way, ratio of the Hubble Constant Ho with the frequency v of CMB is called as the Dark Constant (DC) and it can be expressed as follows,

$$\frac{H_o}{V_{cmb}} = \text{Dark Constant(DC)} \qquad (4)$$

H_o is the Hubble constant and it is expressed in s^{-1} and V_{cmb} is the frequency of CMB radiation in s^{-1}. Like that T_p and T_u can related as

$$\frac{T_p}{T_u} = \text{Dark Constant(DC)} \qquad (5)$$

Where T_p is the Time period in s and T_u is the age of the universe in s

3. Relationship between X-Energy & CMB Temperature (T):

We know that,

$h \times v = 2.8214 \times K \times T$ (According to the Reference paper [18]) (6)

Above equation can be rearranged as:

$$h \times V_{cmb} = 2.8214 \times K \times T \qquad (7)$$

Since E = h x v equation (7) can be rearrange as follows,

$$E_{cmb} = 2.8214 \times K \times T \qquad (8)$$

Where E_{cmb} is the energy of CMB radiation in joule, K is Boltzmann constant and T is the CMB temperature in Kelvin (common to both early and late universes), according to the Reference paper [19] value of the Boltzmann constant is 1.380649 $x10^{-23}$J/k. Substitute

E_{cmb} = Ex/Dark Constant in equation (8):

$$\frac{Ex}{\text{Dark Constant}} = (2.8214) \times (K) \times (T) \qquad (9)$$

Rearranging the above equation (9), we get:

$$Ex = (2.8214) \times (K) \times (T) \times (DC) \qquad (10)$$

Substitute K = 1.380649 $x10^{-23}$, DC = 1.46594448887768 x 10^{-29} in the above equation

(10), we get:

$$Ex = 5.71038605191071 \times 10^{-52} \times T - \qquad (11)$$

(Or)

$$Ex = \Delta \times T \qquad (12)$$

Where Ex is the X- Energy expressed in joule, T is the CMB Temperature in Kelvin and Δ is the Constant and the value is 5.71038605191071$x10^{-52}$ J/K.

Highlight points:

(1) X-ENERGY Ex is directly proportional to the CMB Temperature (T)

(2) This formula can be directly used for the late & the early universe.

(3) Increasing of (T) causes the X-Energy (Ex) to increase.

(4) Decreasing of (T) causes the X-Energy (Ex) to decrease

(5) Points (3) & (4) confirms that the Temperature (T) is very high when the age of the universe is 1s ($T=1.16035414939817x10^{18}K$) see Example 7: and the Temperature (T) is gradually decreases to the present Cosmic Microwave Background Temperature T=2.725K (Value of T according to the Reference Paper [20])

4. Estimating X-Energy:

Example: 1 To find out the X-Energy Ex given that CMB temperature is 2.725 K (according to the Reference paper [20])

We know that,

Ex = Δ x T from equation (12)

$= 5.71038605191071x10^{-52}$ x 2.725

$= 1.55608019914567x10^{-51}J$

Example 1a:

To find out the X - energy (Ex) given that temperature (T) is $1.16035414939817 \times 10^{18}K$

[value T is taken from Example 7] and the age of the universe is 1s.

Solution:

Ex = Δ x T from equation (12)

$= (5.71038605191071x10^{-52}) \times (1.160354 14939817x10^{18}) = 6.62607015x10^{-34}$ J

5. Showing Relationship between X-Energy (Ex) & H_o:

We know that,

$E_{cmb} = h \times v_{cmb}$ from equation (2)

Substitute $V_{cmb} = \frac{1}{T_p}$

We get:

$$Ecmb = \frac{h}{T_p} \quad (13)$$

Substitute $T_p = T_u$ x Dark Constant (DC) from equation (5) to the above equation (13), we get:

$$Ecmb = \frac{h}{T_u \, X \, DC} \quad (14)$$

Substitute Age of the universe $T_u = 1/H_0$ in the above said equation (14), we get:

$$Ecmb = \frac{(h)\,x\,(H_0)}{DC} \quad (15)$$

Substitute E_{cmb} = Ex/DC in the above said equation (15), we get:

$$\frac{Ex}{DC} = \frac{(h)\,x\,(H_0)}{DC}$$

Simplifying the above, we get the final equation as,

$Ex = h \times H_o$ (16)

Where Ex is the X – Energy and it's expressed in Joule, h is the Planck's constant and H_0 is the Hubble's constant expressed is S^{-1}.

6. Showing Relationship between H0 & CMB Temperature (T)

Equating equation (12) & (16) equation

Ex = Δ x T from equation (12)

$Ex = h \times H_o$ from equation (16)

$h \times H_o = \Delta \times T$

Or, $H_o = \Delta \times T/h$, substituting Δ/h as S', we get:

H_o= S' x T (17)

Hubble's constant H_o is directly proportional to the CMB temperature (T) and the above equation (17) clearly shows that the value of H_o depends on the CMB temperature (T). H_o is the Hubble's constant expressed in s^{-1} and S' is a constant & its value is:

$S' = \underline{8.61805855150916x10}^{-19}K^{-1}s^{-1}$ or Hz/K (17a)

7. Solution to Hubble Tension:

There are papers which tries to give solution to the Hubble tension but still the contention over the Hubble constant value presented by these various researches remains. Equation (17) shows the relationship between H_0 & T (CMB Temperature). Current measurement of the CMB Temperature according to the Reference paper [20] is 2.725K and this Temperature is uniform across the sky. Presence of the important relationship between these two (H_0 & T) could eliminate the present issue or tension. This can be explained via two conditions as stated below:

(1) Value of H_0 is correct when the value of (T) equals the present value of 2.725 K (T = 2.725 K)

(2) Value of H_0 is not correct when the value of (T) unequal the value of 2.725 K (T ≠ 2.725 K)

Example: 2

Value of H_0 obtained according to the Planck 2018 of ΛCDM model is 67.04 ± 05 Km/s/Mpc.Find the CMB Temperature?

According to the Reference paper [22] Km/s/Mpc is converted to s^{-1}

→ $67.04 / 3.08567758128 \times 10^{19}$

→ $H_0 = 2.17261843579233 \times 10^{-18} s^{-1}$

We know that, $H_0 = S' \times T$ from equation (17)

$T = \frac{H_0}{S'}$ (From the above equation)

Substituting the values of H_0 and S' as below

$$T = \frac{2.17261843579233x10^{(-18)}}{8.61805855150916x^{(-19)}}$$

Hence, the final resultant value for T is:

$$T = 2.52100681703058K \quad (18)$$

Value of H_0 is not correct since the above result (18) will not equal to the present value of the CMB Temperature whose value is 2.725K. (2.521K ≠ 2.725K)

Example: 3

Value of H_0 obtained according to the SHOES team are 73.04 ± 1.04 Km/s/Mpc. Goal is to find the CMB temperature.

According to the Reference paper [22] Km/s/Mpc is converted to s^{-1}

→ $73.04 / 3.08567758128 \times 10^{19}$

→ $H0 = 2.36706519317231 \times 10^{-18} s^{-1}$ (18a)

We know that, $H_0 = S' \times T$ from equation (17), which can be rewritten as below.

$T = \frac{H_0}{S'}$

Applying the values for S' and H_0 from equations 17a and 18a we get:

$$T = \frac{2.36706519317231x10^{-18}}{8.61805855150916x^{-19}}$$

$$T = 2.74663391879346 \text{ K} \quad (19)$$

Value of H_0 is not correct since the above result (19) will not equal to the present value of the CMB temperature whose value is 2.725K. (2.746K ≠ 2.725)

Example: 4

To find the present value of H_0 when the CMB Temperature is 2.725K

We know that,

→ $H_0 = S' \times T$ from equation (17)

→ = $(8.61805855150916 \times 10^{-19}) \times (2.725)$ (value 2.725K from Reference paper [20]

→ $H_0 = 2.34842095528625 \times 10^{-18} s^{-1}$

Convent the above value H_0 into Km/s/Mpc

→ $H_0 = 72.4646989313493$ Km/s/Mpc

Thus for the present CMB temperature 2.725K correct Hubble's constant H_0 is 72.4646989313493 Km/s/Mpc. This is the solution for the present issue or Hubble tension.

8. Estimating the value of Dark Constant (DC):

Example 5:

To find out the value of Dark Constant given that the X-Energy (Ex) is = $1.556080199145\ 67 \times 10^{-51}$ J (taken from Example 1) and the present CMB temperature is 2.725K and with CMB frequency is 160.2GHz. (The given CMB Temperature and Frequency values are according to Reference paper [20])

Solution:

Dark Constant,(DC) = $\frac{Ex}{E_{cmb}}$ from equation (3)

Substitution, $E_{cmb} = h \times V_{cmb}$ from equation (2), wherein $h = 6.62607015 \times 10^{-34}$ Js (Planck's constant according to the Reference paper [21]

$V_{cmb} = \frac{2.8214KT}{h} = \frac{(2.8214\ x\ 1.380649x10^{-23}x2.725)}{6.62607015x10^{-34}} =$ 160.198491355166 GHz.

(Or) V_{cmb} = 160.2 GHZ approximately.

Substitute h = 6.62607015x10^{-34} & V_{cmb} = 160198491355.166 Hz in the above said equation (2)

E_{cmb} = (6.626070715x10^{-34}) x (160198491355.166)

E_{cmb} = 1.0614864416435x10^{-22} J

Dark Constant,(DC) = $\frac{1.55608019914567x10^{-51}}{1.0614864416435x^{-22}}$ = 1.46594448887768x10^{-29}

9. Estimating the total age of the universe:

Example 6

To estimate the total age of the universe

Solution:

X – Energy, E_x = Δ x T from equation (12)

Put T = 1K in the above said equation, we get:

E_x = Δ

E_x = 5.7103860519107x10^{-52} J

H_0 = S' x T from equation (17)

Put T = 1K in the above said equation

H_0 = S'

Now Hubble's constant.

H_0 = 8.61805855150916x10^{-19}s^{-1}

Convent the above value s^{-1} into Km/s/Mpc

H_0 = 26.5925500665502 Km/s/Mpc

Age of the universe T_u is calculated by the formula

$T_u = \frac{1}{H_0}$

Substitute H_0 = 8.61805855150916x10^{-19} in the above said equation

Age of the universe,

$T_u = \frac{1}{(8.61805855150916x10^{-19})}$ = 1.16035414939417x10^{18}s

(Or)

Converting seconds to Billion Years, total age of the universe is:

T_u = 36.77 Billion Years

10. Estimating the Temperature (T) when the age of the universe is 1 second:

Example: 7

We know that

$$T_u = \frac{1}{H_o}$$

Substitute T_u = 1s in the above equation

We get:

$H_o = 1s^{-1}$

H_o = S' x T from equation (17)

Rearranging the above equation,

$$T = \frac{H_o}{S'}$$

Substitute S' = $8.61805855150916x10^{-19}$ from equation 17a and Ho = 1s in the above said equation, we get the value of T as below:

$$T = \frac{1}{8.61805855150916x10^{-19}} = 1.16035414939817 \times 10^{18}K$$

Thus when the age of the universe is 1s, the value of Temperature (T) is

$1.16035414939817 \times 10^{18}K$

11. Conclusion:

1) Ratio of X-Energy (Ex) with the Energy of CMB radiation (E_{cmb}) is called as the Dark Constant & it's value is $1.46594448887768x10^{-29}$. Throughout the universe it's always be a Constant. [See Example 5:]
2) For the present CMB Temperature (2.725 K), the X-Energy (Ex) is $1.55608019914567x10^{-51}$J. (Example1)
3) When the age of the universe is 1s, value of the Temperature (T) is $1.16035414939817x10^{18}$ K & value of the X-Energy (Ex) is $6.62607015x10^{-34}$ J (Example 7 &1a)
4) Equation (17) shows the relationship between Hubble Constant (H_o) & CMB Temperature T.
5) Since the present CMB Temperature is 2.725K and it's uniform across the sky, with the presence of above mentioned relationship could eliminate the present issue (or) Hubble tension.
6) By using the two conditions, present issue or Hubble tension could be solved.

   Condition 1:

   Value of H_o is correct when the value of (T) equals the present value of 2.725K (T = 2.725K).

   Condition 2:

   Value of Ho is not correct when the value of (T) not equals to the value of 2.725K ($T \neq 2.725$ K).
7) Value of CMB Temperature T differs from each other for the two respective teams. [Example 2 & 3]
   (a) Planck 2018 $\wedge$CDM model is 67.04 ± 05 Km/s/Mpc (H_o) with 2.52100681703058K (T)
   (b) SHOES team are 73.04 ± 1.04 Km/s/Mpc (H_o) with 2.74663391879346K (T)
8) Ho=72.4646989313493 Km/s/Mpc for the present CMB Temperature 2.725K. [refer Example 4:] and this is the solution for the present issue or Hubble tension.
9) Showing the relationship between X- Energy and CMB Temperature (T) with new Constant $\Delta = 5.71038605191071x10^{-52}$J/K
10) Showing the relationship between H_o (Hubble's constant) & CMB Temperature T With new constant S' = $8.61805855150916 \times 10^{-19}s^{-1} K^{-1}$or Hz/K.
11) Total age of the universe is estimated as Tu = 36.77 Billion Years [see Example 6:]

12. Acknowledgement:

We hereby acknowledge the following personnel for their contribution to this paper:

1. Hare Krishna Charitable Trust, Tiruchendur, Tamilnadu, for their charitable support necessary for procuring relevant books and research materials.

2. Vaibhav Ram, Karthik Srinivasan and Sridhar Srinivasan for their support with English grammar checking, typing, formatting and layout.

13. References:

[1] Leavitt, Henrietta S. 1907. *1777 variables in The Magellanic Clouds.* Annals of Harvard College Observatory, Vol. 60, pp. 87-108.3.
(NASA ADS)

[2] Slipher, V. M. 1917. *Nebulae.* Proceedings of the American Philosophical Society, Vol. 56, p.403-409.
(NASA ADS)

[3] Lemaitre, G. March 1931. *A homogeneous universe of constant mass and increasing radius accounting for the radial velocity of extra - galactic nebulae.* Monthly Notices of the Royal Astronomical Society, Vol. 91, Issue 5, pp. 483-490.
(NASA ADS)

[4] Resolutions presented at the XXXth General Assembly of the International Astronomical Union, https:// www.iau.org/ news/press releases/detail/iau 1810 (2018).

[5] Hubble, E. 1929. *A relation between distance and radial velocity among extra-galactic nebulae.* Proceedings of the national academy of sciences,15 (3), 168-173.
(Google Scholar)

[6] Aghanim et al., 2020. *Planck 2018 results-VI. Cosmological parameters.* Astronomy & Astrophys, 641, id.A6, 67 pp.
(NASA ADS)

[7] AG Riess et al., 2022. *A comprehensive measurement of the local value of the Hubble constant with 1 Km/s/Mpc uncertainty from the Hubble Space Telescope and the SHOES team.* The Astrophysical Journal letters, 934 (1),L7.
(Google Scholar)

[8] Edvard Mortsell et al., 2022.*The Hubble tension revisited: additional local distance ladder uncertainties.* The Astrophysical Journal,935 (1), 58.
(Google Scholar)

[9] Poulin, V. Smith, TL. Grin, D. Karwal, T. and Kamionkowski, M. 2018. *Cosmological implications of ultralight axion like fields.* Physical Review, D 98 (8), 083525.
(Google Scholar)

[10] Schiavone, T. Montani, G. Bombacigno, F. 2023. *f (R) gravity in the Jordan frame as a paradigm for the Hubble tension.* Monthly Notices of the Royal Astronomical Society: Letters 522 (1), L72-L77.
(Google Scholar)

[11] Nojiri, S. Odintsov, SD. Oikonomou, VK. 2022. *Integral F(R) gravity and saddle point condition as a remedy for the* H_o *-tension* . Nuclear Physics, B 980 , 115850.
(Google Scholar)

[12] Jesus, AS. Pinto-Neto, N. Queiroz, FS. Silk, J. Silva, DR. 2023, *The hubble rate trouble: an effective field theory of dark matter.* The European Physical Journal, C 83 (3), 203.
(Google Scholar)

[13] Gao, LY. Xue, SS. Zhang, X. 2024. *Dark energy & matter interacting scenario to relieve Ho and S8 tensions* .Chinese Physics, C 48 (5), 051001.
(Google Scholar)

[14] Escamilla-Rivera, C. Torres Castillejos, R. 2022, *Ho Tension on the Light of Supermassive Black Hole Shadows Data.* Universe, 9 (1), 14.
(Google Scholar)

[15] Gupta, I. 2023. Using grey sirens to r*esolve the Hubble-Lemaitre tension.* Monthly Notices of the Royal Astronomical Society, 524 (3), 3537-3558.
(Google Scholar)

[16] Cea, P. 2022. The e*llipsoidal universe and the Hubble tension.* arXiv preprint arXiv:2201.04548.
(Google Scholar)

[17] Suresh, PK. 2023. *A possible solution to the Hubble tension from quantum gravity.* arXiv preprint arXiv:2303.02953.
(Google Scholar)

[18] Wikipedia, LibreTexts, *Deriving the Wien's displacement law from the Planck's law* https://chem.libretexts.org/Bookshelves

[19] Fellmuth, B. Gaiser, C. Fischer, J. 2006. *Determination of the Boltzmann constant - status and prospects* . Measurement Science and Technology, 17 (10), R145.

(Google Scholar)

[20] Nones, C. Marnieros, S. Benoit, A. Berge, L. Bideaud, A. Camus,P. Dumoulin, L. Monfardini, A. and Rigaut, O. 2012. *High - impedance NbSi TES sensors for studying cosmic microwave background radiation.* Astronomy & Astrophysics, 548, A17.

(Google Scholar)

[21] Huang, J. Wu, D. Cai, Y. Xu, Y. Li, C. Gao, Q. Zhao, L. Liu, G. Xu, Z. Zhou, XJ. 2020. *High precision determination of the Planck constant by modern photoemission spectroscopy.* Review of Scientific Instruments, 91(4).

(Google Scholar)

[22] https://www.unitconverters.net/length/megaparsec-to-kilometer.htm

[23] Haug, EG. Tattum, ET. Falsensvei, CM. 2024. *Solving the Hubble tension by extracting current CMB temperature from the Union 2 supernova database.* Hal archive – researchgate.net

(Google Scholar)