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

The Exact Commence of the Epoch of Reionization

Subramanian. S, Independent Researcher, Electrical and Electronics Engineering (Diploma)
Gomathi Ambal Polytechnic, Maveeran Pooli Thevar Nagar, Malaiyadikurichi – 627 755,
Thirunelveli – District, Tamilnadu, India.
No.77a/34, Veeraperumal Koil Street, Mylapore, Chennai – 600 004, India

Abstract:

This paper presents detailed information about the universe which goes through a new Radiation called Cosmic Background Radiation and this can be classified on the basis of the energy photons from higher to lower levels and we calculate the Epoch of each Radiation by using the Dark Constant which is the ratio of X- Energy with Cosmic Background Radiation Energy or it's each Energy Radiation. We establish the well relationship between X-Energy & Cosmic Background Radiation Temperature (T) as well as the relation between X-Energy & Ho. Using all these relations we derive the correct value for Ho and the Temperature T of Cosmic Background Radiation (CBR). In this research paper we finally estimate the Epoch of each Radiation of CBR & as well as the exact commence of the Epoch of Reionization (EoR) which was occurred during the early universe at which the Age of the Universe, Tu = 652619.9959 Years with H_o = 1498287.37413118 Km/s/Mpc after the Big Bang.

Keywords:

X-Energy, Dark Constant, Hubble constant, age of the universe, Cosmic Background Radiation, CMB, early universe and late universe, Epoch of Reionization, Helium Reionization.

1. Introduction:

In the history of the early universe, neutral hydrogen atoms of the gas clouds were ionized by the Ultraviolet - radiation which was emitted from the first stars and this process was called Reionization. There is a tension or an issue continuing in the field of Cosmology regarding (EoR) Epoch of Reionization. About 400 million years, when the Dark Ages ended, with the start of the next epoch (EoR) after the Big Bang mentioned by the author in his introduction & summary sections [1]. Ending of the Epoch of Reionization (EoR) at z = 5.3 (redshift) with t = 1.1 Billion years using Lyman - α optical depth with XQR - 30 sample [2]. JWST observations clearly show the production of higher ionized photons during the reionization process and the observed galaxies not only commence reionization but also ended this reionization a bit previously [3]. Ultraviolet photons emerging from O & B stars with higher energy (hv>13.6ev) which ionize the hydrogen atom and produce H II around the regions of the O & B stars [4]. Light from the very first source began to reionize most of the hydrogen atoms at (z = 7) with t = 700 Million Years [5] are the papers here regarding (EoR) Epoch of Reionization.

When did the (EoR) start? What's the exact start & end time regarding Epoch of Reionization (EoR)? Why do some models with experimental methods don't give satisfied results or differ in their results? But (EoR) tension/issue still exists and there is no clear solution or picture or idea for this present issue and this paper will provide a complete solution to this present tension / issue. In this paper, we introduce a new radiation. Universe always goes through this new radiation (CBR) after the Big Bang when it's age was one second (early universe) to the late universe. This Cosmic Background Radiation (CBR) emerged during the Big Bang. Ratio of X-Energy with this Cosmic Background Radiation (CBR) energy is called as Dark Constant (DC) [6]. Since this Radiation is an Electromagnetic Radiation and this can be classified in this research paper according to the "Electromagnetic - Spectrum Table" which was presented by NASA [7]. The value of Planck's constant (h) used in our calculations is $6.62607015 \times 10^{-34}$ Js [9].

2. Classification of CBR:

CBR can be classified on the basis of their energy photons from higher to lower levels with different names are given below.

1. Cosmic Gamma - ray Background Radiation (CGB)
2. Cosmic X - ray Background Radiation (CXB)
3. Cosmic Ultraviolet Background Radiation (CUB)
4. Cosmic Optical Background Radiation (COB)
5. Cosmic Infrared Background Radiation (CIB)

6. Cosmic Microwave Background Radiation (CMB)
7. Cosmic Radio Wave Background Radiation (CRB)

3. Estimating the Epoch of each Radiation of CBR:

Since the Universe goes through the above said Radiations & the Epoch of each Radiation can be calculated by using "Dark Constant"(DC)[5]. Dark Constant is the ratio of X - Energy with (CBR) energy (Cosmic Background Radiation) or it's each energy Radiation as classified above. Using this ratio we establish the relation between X-Energy & Temperature of CBR as well as the relation between X-Energy & Ho. Using all these relations we derive the correct value for H_o and it's associated CBR (T). This is the methodology which we apply in this paper. We now proceed to provide the proofs with equations & some examples.

Example 1:

To find out the Epoch of Cosmic Gamma - ray Background Radiation given that Energy, $E > 2\times10^{-14}J$

Solution:

Since "Dark Constant "(DC) is the ratio of X - Energy with CBR or it's each energy Radiation,

$$\text{Dark Constant (DC)} = \frac{\text{X-Energy}}{\text{CGB- Energy}} \quad (1)$$

Since $E = h\nu = 2\times10^{-14}J$, equation (1) can be written as,

$$\text{X-Energy} = \text{DC} \times \text{CGB- Energy} \quad (2)$$

$$\rightarrow (1.46594448887768 \times10^{-29}) \times (2\times10^{-14})$$

$$\text{X - Energy} = 2.93188897775536\times10^{-43}J$$

According to the reference paper [5], X-Energy, $Ex = h\times H_o$ (3)

Above equation (3) can be written as follows,

$$H_o = \frac{Ex}{h} \quad (4)$$

Substitute $Ex = 2.93188897775536\times10^{-43}J$ & $h = 6.62607015\times10^{-34}J\ s$ in the above said equation (4),

$$= \frac{(2.93188897775536\times10^{-43})}{(6.62607015\times10^{-34})}$$

$$H_o = 4.42477805302946\times10^{-10}\ s^{-1}$$

We know that, Age of the Universe, Tu is given by,

$$Tu = \frac{1}{H_o} \text{ from equation (1)} \quad (5)$$

$$= \frac{}{(4.42477805302946\times10^{-10})}$$

$$= 2260000361.63473\ s$$

Or

$$Tu = 71.6166 \text{ Years}$$

Result:

Thus the Epoch of (CGB) Cosmic Gamma - ray Background Radiation starts from 1s and ends at 71.6166 Years after the Big Bang.

Example 2:

To find out the Epoch of Cosmic X - ray Background Radiation given that Energy, $E = (2\times10^{-17}J - 2\times10^{-14}J)$

Solution:

Since "Dark Constant" (DC) is the ratio of - Energy with CBR or it's each energy Radiation,

$$\text{Dark Constant (DC)} = \frac{\text{X-Energy}}{\text{CXB -Energy}} \quad (6)$$

Since $E = h\nu = (2\times10^{-17}J)$, equation (6) can be written as,

$$\text{X-Energy} = \text{DC} \times \text{CXB- Energy} \quad (7)$$

$\rightarrow (1.46594448887768 \times 10^{-29}) \times (2 \times 10^{-17})$

X - Energy = $2.93188897775536 \times 10^{-46}$J

According to the reference paper [5],

X-Energy, Ex = $h \times H_o$ from equation (3)

Above equation (3) can be written as follows,

$$H_o = \frac{Ex}{H} \text{ from equation} \quad (4)$$

Substitute Ex = $2.93188897775536 \times 10^{-46}$J & h = $6.62607015 \times 10^{-34}$J s in the above said equation (4),

$$= \frac{(2.93188897775536 \times 10^{-46})}{(6.62607015 \times 10^{-34})}$$

$$H_o = 4.42477805302946 \times 10^{-13}\ s^{-1}$$

We know that, Age of the Universe, Tu is given by,

$$Tu = \frac{1}{H_o} \text{ from equation} \quad (5)$$

$$= \frac{(1)}{(4.42477805302946 \times 10^{-13})}$$

= 2260000361634.73 s

Or

Tu = 71616.5605 Years

Result:

Thus the Epoch of Cosmic X- ray Background Radiation (CXB) starts from 71.6166 Years and ends at 71616.5605 Years after the Big Bang.

Example 3:

To find out the Epoch of Cosmic Ultraviolet Background Radiation given that Energy, E = $(5\times10^{-19}J - 2\times10^{-17}J)$

Solution:

Since "Dark Constant "(DC) is the ratio of X - Energy with CBR or it's each energy Radiation,

$$\text{Dark Constant (DC)} = \frac{\text{X-Energy}}{\text{CUB-Energy}} \quad (8)$$

Since $E = h\nu = (5\times10^{-19}\,J)$, equation (8) can be written as,

$$\text{X-Energy} = \text{DC} \times \text{CUB- Energy} \quad (9)$$

$$\rightarrow (1.46594448887768 \times10^{-29})\times(5\times10^{-19})$$

$$\text{X - Energy} = 7.3297224443884\times10^{-48}J$$

According to the reference paper [5],

$$\text{X-Energy, } Ex = h\times H_o \text{ from equation} \quad (3)$$

Above equation (3) can be written as follows,

$$H_o = \frac{Ex}{h} \text{ from equation (4)}$$

Substitute $Ex = 7.3297224443884\times10^{-48}$ J & $h = 6.62607015\times10^{-34}$ J s in the above said equation (4),

$$= \frac{(7.3297224443884\times10^{-48})}{(6.62607015\times10^{-34})}$$

$$H_o = 1.10619451325736\times10^{-14}\ s^{-1}$$

We know that, Age of the Universe, Tu is given by,

$$Tu = \frac{1}{H_o} \text{ from equation} \quad (5)$$

$$= \frac{(1)}{(1.10619451325736\times10^{-14})}$$

$$= 90400014465389.3 \text{ s}$$

Or

$$Tu = 2.8647 \text{ Million Years}$$

Result:

Thus the Epoch of Cosmic Ultraviolet Background Radiation starts from 71616.560

5 Years and ends at 2.8647 Million Years after the Big Bang.

Example 4:

To find out the Epoch of Cosmic Optical Background Radiation given that Energy, E = (3×10^{-19}J - 5×10^{-19}J)

Solution:

Since "Dark Constant "(DC) is the ratio of X - Energy with CBR or it's each energy Radiation

$$\text{Dark Constant (DC)} = \frac{\text{X- Energy}}{\text{COB - Energy}} \quad (10)$$

Since E = h v = (3×10^{-19}J), equation (10) can be written as,

X-Energy = DC × COB- Energy (11)

→ $(1.46594448887768 \times10^{-29})\times(3\times10^{-19})$

X - Energy = $4.39783346663304\times10^{-48}$J

According to the reference paper [5],

X-Energy, Ex = $h\times H_o$ from equation (3)

Above equation (3) can be written as follows,

$$Ho = \frac{Ex}{h} \text{ from equation} \quad (4)$$

Substitute Ex = $4.39783346663304\times10^{-48}$J & h = 6.62607015×10^{-34}J s in the above said equation (4),

$$= \frac{(4.39783346663304\times10^{-48})}{(6.62607015\times10^{-34})}$$

$H_o = 6.63716707954419\times10^{-15}\ s^{-1}$

We know that, Age of the Universe, Tu is given by,

$$Tu = \frac{1}{H_o} \text{ from equation} \quad (5)$$

$$= \frac{(1)}{(6.63716707954419\times10^{-15})}$$

= 150666690775649 s

Or

Tu = 4.7744 Million Years

Result:

Thus the (COB) Epoch of Cosmic Optical Background Radiation starts from 2. 8647 Million Years and ends at 4.7744 Million Years after the Big Bang.

Example 5:

To find out the Epoch of Cosmic Infrared Background Radiation given that Energy,

E = (2×10^{-22}J - 3×10^{-19}J)

Solution:

Since "Dark Constant "(DC) is the ratio of X - Energy with CBR or it's each energy Radiation,

$$\text{Dark Constant (DC)} = \frac{\text{X- Energy}}{\text{CIB- Energy}} \quad (12)$$

Since E = h v = (2×10^{-22}J), equation (12) can be written as,

X-Energy = DC × CIB- Energy (13)

→ $(1.46594448887768 \times10^{-29})\times(2\times10^{-22})$

X - Energy = $2.93188897775536\times10^{-51}$J

According to the reference paper [5],

X-Energy, Ex = $h\times H_o$ from equation (3)

Above equation (3) can be written as follows,

$$H_o = \frac{Ex}{h} \text{ from equation} \quad (4)$$

Substitute Ex = $2.93188897775536\times10^{-51}$J &

h = 6.62607015×10^{-34}J s in the above said equation (4),

$$= \frac{(2.93188897775536\times10^{-51})}{(6.62607015\times10^{-34})}$$

$$H_o = 4.42477805302946\times10^{-18}\ s^{-1}$$

We know that, Age of the Universe, Tu is given by,

$$Tu = \frac{1}{H_o} \text{ from equation} \quad (5)$$

$$= \frac{(1)}{(4.42477805302946\times10^{-18})}$$

$$= 2.26000036163473\times10^{17}\ s$$

Or

Tu = 7.1617 Billion Years

Result:

Thus the Epoch of Cosmic Infrared Background Radiation starts from 4.7744

Million Years and ends at 7.1617 Billion Years.

Example 6:

To find out the Epoch of Cosmic Microwave Background Radiation given that Energy,

E = $(2\times10^{-24}$J - 2×10^{-22}J)

Solution:

Since "Dark Constant "(DC) is the ratio of X - Energy with CBR or it's each energy Radiation,

$$\text{Dark Constant (DC)} = \frac{\text{X-Energy}}{\text{CMB-Energy}} \quad (14)$$

Since E = h v = $(2\times10^{-24}$J), equation (14) can be written as,

X-Energy = DC × CMB- Energy (15)

→ $(1.46594448887768\times10^{-29})\times(2\times10^{-24})$

X - Energy = $2.93188897775536\times10^{-53}$J

According to the reference paper [5],

X-Energy, Ex = $h\times H_o$ from equation (3)

Above equation (3) can be written as follows,

$$H_o = \frac{Ex}{h} \text{ from equation (4)}$$

Substitute Ex = $2.93188897775536\times10^{-53}$J & h = 6.62607015×10^{-34}J s in the above said equation (4)

$$= \frac{(2.93188897775536\times10^{-53})}{(6.62607015\times10^{-34})}$$

$$H_o = 4.42477805302946\times10^{-20}$$

We know that, Age of the Universe, Tu is given by,

1

$Tu = \frac{1}{H_o}$ from equation (5)

$= \frac{(1)}{(4.42477805302946\times10^{-20}\ s^{-1})}$

$= 2.26000036163473\times10^{19}$ s

Or

Tu = 716.1656 Billion Years

Result:

Thus the Epoch of Cosmic Microwave Background Radiation starts from 7.1617 Billion Years and ends at 716.1656 Billion Years.

Example 7:

To find out the Epoch of Cosmic Radio wave Background Radiation given that Energy,

$E < 2\times10^{-24}$J

Solution:

We know that,

$H_o = S' \times T$ (Ref. paper [5]) (16)

Above said equation (16) can be written as,

$T = \frac{H_o}{S'}$ (17)

Put Ho = 1 Km/s/Mpc. According to the Ref.paper [8], Km/s/Mpc is converted into s^{-1}

$\rightarrow 1/3.08567758128\times10^{19}$

$\rightarrow H_o = 3.24077928966636\times10^{-20}\ s^{-1}$

Substitute ($S' = 8.61805855150916\times10^{-19}\ s^{-1}$) and ($Ho = 3.24077928966636\times10^{-20} s^{-1}$) in the above said equation (17)

$T = \frac{(3.24077928966636\times10^{-20})}{(\ 8.61805855150916\times10^{-19}\ )}$

T = 0.03760451696048 K

We know that,

X-Energy, $Ex = h\times H_o$ from equation (3)

$= (3.24077928966636\times10^{-20})\ (6.62607015\times10^{-34})$

$Ex = 2.14736309139965\times10^{-53}$ J

Since "Dark Constant "(DC) is the ratio of X - Energy with CBR or it's each energy Radiation,

$\text{Dark Constant (DC)} = \frac{\text{X-Energy}}{\text{CRB-Energy}}$ (18)

Equation (18) can be written as,

$\text{CRB-Energy} = \frac{\text{X-Energy}}{\text{Dark Constant (DC)}}$ (19)

Substitute $Ex = 2.14736309139965\times10^{-53}$ & $(DC) = 1.46594448887768\times10^{-29}$ in the above equation (19)

$= \frac{2.14736309139965\times10^{-53}}{1.46594448887768\ \times10^{-29}}$

$CRB\text{-}Energy = 1.46483247332487\times10^{-24}$J

We know that, Age of the Universe, Tu is given by,

$Tu = \frac{1}{H_o}$ from equation (5)

(1)

$$= \frac{}{(3.24077928966636\times10^{-20})}$$

Tu = $3.08567758128\times10^{19}$ s

Or

Tu = 977.8123 Billion Years

Result:

Since the value ($1.46483247332487\times10^{-24}$J) < ($2\times10^{-24}$J) and confirms the Radiation is Cosmic Radio wave Background Radiation & the Temperature (T) associate with this CRB Radiation is T = 0.03760451696048 K which is very nearer to the Absolute Temperature 0 Kelvin & the value of H_o = 1 Km/s/Mpc. Now substitute

H_o= 0 Km/s/Mpc in the above said equation (17), we get,

$$= \frac{(0)}{(8.61805855150916\times10^{-19})}$$

T = 0 K (Absolute Temperature)

Thus, the expansion of the Universe will comes to end when the value of H_o = 0 Km/s/Mpc & the associated Temperature (T) of the CRB reaches (Absolute Temperature) 0 Kelvin. Without the expansion rate (H_o), is it possible for the Time (Tu) to continue its long term journey? Thus the Time (Tu) will be undefined without Ho. Thus the Epoch of Cosmic Radio wave Background Radiation starts from 716.1656 Billion Years and ends at 977.8123 Billion Years.

8. Final Stages of the Universe:

Final stages of the universe can be classified as follows by three conditions.

8.1 Total age of the universe:

Total age of the universe is estimated as 36.77 Billion Years with the main condition–associated Temperature (T) of CMB=1K [5].

8.2 Ultimate age of the universe:

Ultimate age of the universe is estimated as 977.8123 Billion Years with the main condition – associated Temperature (T) of CRB = 0.03760451696048 K.

8.3 Death end of the age of the universe:

The expansion of the Universe will comes to end when the value of H_o = 0 Km/s/Mpc & the associated Temperature (T) of the CRB reaches (Absolute Temperature) 0 Kelvin.

9. Solution to the tension regarding EoR:

Example 8:

Ultraviolet photons with higher energy value having (hv > 13.6 ev) is enough for the hydrogen atom to ionize. In this example we take E = 13.7ev which is greater than 13.6ev

Solution:

Since "Dark Constant "(DC) is the ratio of X - Energy with CBR or it's each energy Radiation,

$$\text{Dark Constant (DC)} = \frac{\text{X-Energy}}{\text{CUB-Energy}} \quad (20)$$

Since E = h v = 13.7ev or 2.19474×10^{-18} J, equation (20) can be written as,

X-Energy = DC × CUB- Energy (21)

$\rightarrow 1.46594448887768 \times10^{-29} \times2.19474\times10^{-18}$

X - Energy = $3.2173670075194\times10^{-47}$J

According to the reference paper [5],

X-Energy, Ex = h×H_o from equation (3)

Above equation (3) can be written as follows,

$$H_o = \frac{Ex}{h} \text{ from equation} \quad (4)$$

Substitute Ex =$3.21736700775194\times10^{-47}$ J & h = 6.62607015×10^{-34}J s in the above said equation (4)

$$(3.21736700775194\times10^{-47})$$

$$= \frac{}{(6.62607015\times10^{-34})}$$

$$H_o = 4.85561869205293\times10^{-14}s^{-1}$$

We know that, Age of the Universe, Tu is given by,

$$Tu = \frac{1}{H_o} \text{ from equation} \quad (5)$$

$$= \frac{(1)}{(4.85561869205293\times10^{-14})}$$

Tu = 20594697883437.1 s

Or

Tu = 652619.9959 Years

Result:

Thus the Epoch of Reionization (EoR) occurred when the Age of the Universe, Tu = 652619.9959 Years and the expansion rate $H_o = 4.85561869205293\times10^{-14}\ s^{-1}$ or with the expansion rate H_o = 1498287.37413118 Km/s/Mpc after the Big Bang and also the above said value Tu = 652619.9959 Years (EoR) falls in between 71616.5605 Years to 2.8647 Million Years confirming that the Epoch of Reionization (EoR) occurred during the Epoch of Cosmic Ultraviolet Background Radiation see (Example 3).

9. Conclusion:

1. The Epoch of (CGB) Cosmic Gamma-ray Background Radiation starts from 1s and ends at 71.6166 Years after the Big Bang.
2. The Epoch of Cosmic X- ray Background Radiation (CXB) starts from 71.6166 Years & ends at 71616.5605 Years after the Big Bang
3. The Epoch of (CUB) Cosmic Ultraviolet Background Radiation starts from 71616.560 Years & ends at 2.8647 Million Years after the Big Bang.
4. The Epoch of (COB) Cosmic Optical Background Radiation starts from 2.8647 Million Years & ends at 4.7744 Million Years after the Big Bang.
5. The Epoch of (CIB) Cosmic Infrared Background Radiation starts from 4.7744 Million Years & ends at 7.1617 Billion Years.
6. The Epoch of (CMB) Cosmic Microwave Background Radiation starts from 7.1617 Billion Years and ends at 716.1656 Billion Years.
7. The Epoch of (CRB) Cosmic Radio wave Background Radiation starts from 716.1656 Billion Years & ends at 977.8123 Billion Years.
8. Ultimate age of the universe is estimated as 977.8123 Billion Years with the main condition – associated Temperature (T) of the CRB reaches 0.03760451696048 K.
9. The expansion of the Universe will comes to end when the value of H_o = 0 Km/s/Mpc & the associated Temperature (T) of the CRB reaches (Absolute Temperature) 0 Kelvin is called the "Death end of the Age of the Universe".
10. The exact commence of the Epoch of Reionization (EoR) which was occurred during the early universe at which the Age of the Universe, Tu = 652619.9959 Years with H_o = 1498287.37413118 Km/s/Mpc after the Big Bang.

10. Acknowledgement:

We hereby acknowledge the following personnel for their contribution to this paper. Hare Krishna Charitable Trust, Tiruchendur, Tamilnadu for their charitable support necessary for procuring relevant books and materials. Vaibhav Ram, Karthik Srinivasan and Sridhar Srinivasan for their support with English grammar checking, typing and formatting and layout.

11. References:

[1] Zaroubi, S. 2013. *The Epoch of Reionization*, *The First Galaxies*, Astrophysics and Space Science Library, Volume 396. ISBN 978-3-642-32361-4. Springer-Verlag Berlin Heidelberg, pp. 45
DOI: https://doi.org/10.1007/978-3-642-32362-1_2

[2] S.E.I Bosman et al., 2022. *Hydrogen reionization ends by z = 5.3: Lyman-α optical depth measured by the XQR - 30 sample*. Monthly Notices of the Royal Astronomical Society, Volume 514, Issue1, pp. 55 - 76, DOI:

https://doi.org/10.1093/mnras/stac1046

[3] Munoz, JB. Mirocha, J. Chisholm, J. Furlanetto, SR. Mason, C. 2024. *Reionization after JWST: a pzoton budget crisis*?. Monthly Notices of the Royal Astronomical Society: Letters, Volume 535,Issue 1, pp. L37 - L43, DOI: https://doi.org/10.1093/mnrasl/slae086

[4] Pound, MW. Wolfire, MG. 2011. PDRT: *PhotoDissociation Region Toolbox*. Astrophysics Source Code Library, ascl: 1102.022

[5] Barkana, R. Loeb, A. 2001. *In the beginning: the first sources of light and the reionization of the universe*. Physics reports, 349 (2), 125-238. https://doi.org/10.1016/S0370-1573(01)00019-9

[6] Subramanian, S. 2024. *Complete Solution to the Hubble tension from Cosmic Microwave Background Radiation Temperature*. JETIR Journal, Volume 11, Issue 9, d160 - d167, DOI: http://doi.one/10.1729/Journal.41552

[7] Wavelength, Frequency and Energy - Imagine the Universe. https://imagine.gsfc.nasa.gov/science/toolbox/spectrum_chart.html https://www.unitconvertors.net/length/megaparsec-to-kilometer.htm

[9] 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).DOI: https://doi.org/10.1063/1.5129140