

## **The Ascendency of Cosmological Redshift in Contrast to a Created Universe in Depicting the Cosmos**

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### **Abstract**

In Physics, a redshift is a physical phenomenon incurred in our practically acclaimed ambience which signifies a practicable scenario where the wavelength of electromagnetic radiation, précised illustration of which includes light waves that experiences intensification in their wavelengths and a deceleration in their resulting accompanied frequencies and emission of photon energies. The contrast is the scenario when the wavelengths suffer a gradual and continuum deceleration and an ensuing upsurge in frequency and energy, termed as blueshift or negative redshift. It is a known fact that the blue and red are the two colours that fabricate the two extremities of the visible conceivable spectrum of the light ray bands. The fundamental grounds of electromagnetic redshift mechanism, described in the subject arena of Astronomy and Physical Cosmology, depict the comparative motions exhibited by the celestially engrained radiation springs that in due course bring about the Relativistic Doppler Effect and supplementarily substantiates about the gravitational potentials, which are predominantly due to gravitationally redshifted diminishing radiation mechanisms. All adequately remoted springs of light waves in the cosmos exhibit cosmological redshift. The Big Bang Cosmology is the most mysterious yet explanatory cosmological speculative mechanism explicated in the cosmos which in a simpler sense is lengthening far beyond the degree of human captivating boundaries. It is for such proffering mechanisms incurred in the cosmos, Astrophysicists and space scientists had been putting vigorous mathematically aggrandized analytical computational and scientific interpretations to through light on the super extreme environments and primary early time epochs which might be necessarily standing as additionally intriguingly exploratory. George

Lemaitre had nomenclature this initial early time eon as primeval atom while another Astrophysicist named George Gamow, a Soviet and American polymath, theoretical physicist and cosmologist whose name can be uttered as an early provocatory and developer of Lemaitre's Research promoter on Big Bang Cosmology, as ylem.

**Keywords:** Doppler Effect, Expansion, Hubble, Redshift, Universe.

### Introducing the Effectual Phenomena Redshift in Depicting the Universe

Redshift or more precisely the cosmological redshift is cosmologically observable substantiation occurring as an outcome of light waves traversing through interstellar province and subsequently experiences stretching apart from an observer on account of the exponential spreading out of the observable cosmos. The frequency or the rate of expansion at which the cosmos has been incessantly spreading out is directly proportional to the extent of stretching apart of associated light waves traversing through interstellar domain and reaching the red strata of the light spectrum. The logical presumption behind the cosmological spectacle, the redshift predicts that the larger the redshift, the larger the expanse travelled by the light waves.



**Figure 1:** Depicting Redshift Phenomenon for an observer on Earth.

The linear relationship bridging a functional correspondence between the physical parameters viz., velocity and distance traversed by an object which have been be subject to the universe during the motion of a celestial object has been appraised as

$$v = H_0 D$$

where  $v$  stands for the recessional velocity of the celestial object,  $H_0$  the Hubble Constant and  $D$  represents the appropriate remoteness traversed by an interstellar object for an observer on Earth.

Astronomers set for investigation of the redshift mechanism by figuring out the redshift parameter  $z$ . The parameters associated with wavelength  $\lambda$  can be expressed with the following formula. Thus, we have

$$z = \frac{\lambda_{observed} - \lambda_{rest}}{\lambda_{rest}}$$

where

$\lambda_{observed}$  is the observed wavelength of a spectral line.

$\lambda_{rest}$  is the presumed wavelength of the line when the source is stationary or static in nature.

$z$  precisely calculates the time spans usually computed in terms of light years taken by light waves to reach the Earth, those emanated from the interstellar objects. Yet this does not essentially denote the actual remoteness of the celestial object computed in terms of light years from an observer on Earth. This is due to the reason that the universe has been experiencing an escalating streaming out in every permissible direction and eventually this affects the light waves as it has been traversing across space and the object is now practicalized to be co-ordinated much detached away.

The value of the cosmological redshift gives rise to the recession velocity along with its numerical detachment from the observer sitting on planet Earth. Diminutive velocity encompassed by the drifting apart of the interstellar object engraining insignificant value to a larger extent in comparison to the speed of light waves or extremely speedy photon particles obeys the following mathematical equation combing the cosmological redshift  $z$  and the recession velocity  $v$  as

$$z \approx \frac{v}{c}$$

A straightforward recession velocity  $v$  can be expressed by introducing and consequently multiplying the co-moving separation/ unfastening numeral of the celestial body with the Hubble Constant  $H_0$ , on the verge of the redshifted province of space as under [1]:

$$z \approx \frac{H_0 D_1}{c} - 1$$

satisfying the constraint inequality,

$$D_1 \ll \frac{c}{H_0}$$

The cosmological redshift has been additionally explicated as an upshot of Doppler shifting taking place due to the accepted progression of recession mechanism of furthest cosmological entities [1].

Einstein's field equations of General Relativity elevate as an advantageous pedestal in sketching the mathematically expounding foundation portraying a homogeneous and isotropic cosmos for which the experimental inferences have been drawn from this Doppler shifting effect.

$$1 + z = \frac{a_{now}}{a_{then}}$$

Here  $a$  is the time-dependent cosmological scale factor which has the criteria of possessing strictly and monotonically increasing function of time i.e.,

$$z = f(t), \text{ as } t \rightarrow \infty, z \rightarrow +\infty$$

As an upshot of which,  $z$  is assuming only positive values and stretching up to positive infinite direction, in consequence, the furthest galaxies materialize to be redshifted along the spectrum of the light band [1].

The standardized cosmological model indicates that the scale factor of the cosmos is accelerating and in a hypothesized epoch confirming a dominance of the cosmological constant introduced by Albert Einstein, i.e., a static universe and submissive to gravity, this has been raised a potential to augment in an exponential manner. This spreading out mechanism is uniformly identically distributed for every instance of time and has its representation by means of an unaltered or fixed at each point of time is emerging as a constant term possessing negligible value, named after Edwin Hubble as Hubble Constant.

The very equations of Classical General Relativity had been operational in pervading the mechanisms functioned during the evolution of Big Bang Cosmology. The postulates or generalized presumptions are not implicational at the very early time instances of cosmic time in which the temperature of the cosmos escalated to reach the measured demarcation of Planck Scale. In the subject arena of Cosmology, the Planck temperature scale refers to a theoretically acclaimed maximum attainment of temperature, considered to be the surprisingly hottest reachable point of temperature scale which has been estimated to be nearly reaching an appraisal of temperature elevation as  $1.416808 \times 10^{32}$  Kelvin and this has been prioritized to get assembled with the cosmic ambience of ultimate initial epoch of the evolution of the universe, just after a fraction of second after the Big Bang cosmological phenomena, at such instance of which all the forces of the cosmos might have been integrated as a single force and rendering enormous heat and energy.

## **2.0 Techniques Employed in Appraising the Scaffold of the Conceivable Universe:**

The Astrophysicists and space scientists of present epoch have been incessantly employing three principal techniques to arrive at an appropriate numerical value of the Hubble Constant to apprehend about a précised apprise of the universe are as follows:

- With the aid of carrying out interstellar investigation by making rigorous observations of the celestial entities such as the gigantic stars, greatest colossal explosions incurred in stars i.e., the supernovae blasts, the sturdy black holes, galaxy or cluster of galaxies, the Solar System etc. in their entire movement history starting from their identification in the vast cosmic expanse followed by their traversal journey in the cosmological terrain, continuing the redshift experienced by them till the extreme remoteness accomplished by these celestial objects entailing the exponential stretching apart from an observer on the Earth

essentially apprehending the substantiating of the dominant prevalence of dark energy in the cosmos.

- By means of employing gravitational waves from the colossal collisions of black holes, the region of space where gravity is so strong that nothing can escape from this region i.e., the black hole strata of interstellar province or neutron stars, strongly substantiating Albert Einstein's Theory of General Relativity, depicting the mechanism how gravity ruptures or deforms the configuration or the structure of space-time. The theory of General Relativity affirms that gravity is the consequence of distortions incurred in the presumed geometry of space assimilating the time factor of space i.e., the space-time created by mass and energy. The principle of equivalence asserts that both mass and acceleration encompassed by the interstellar entity disfigure space-time. The theory of General Relativity illustrates the force of gravity as a consequence of curvature of space and time which in turn explicates the extent how far gravity impinges on the large-scale structure of the observable cosmos.

Einstein predicted in his postulated theory of General Relativity that a sturdy pulling force which acts as gravity distorts/disfigures the fabric of space-time by triggering it to curve in the close vicinity of gigantic entities, effectively forming a warp in the space-time spreading out expanses, the additional mass an entity pertains, the grander is the extent of curvature and as a result of which the sturdier will be its gravitational drag on closely proximitized entities. Gravity also distresses the drift of time scales, instigating time to track gradual relaxed manner in the provinces with stronger gravity such as in the near vicinity of a colossal black hole. When light ways progress very close to an enormously large object such as the cluster of galaxies, the curvature of space-time twists the path of the light rays which eventually structures numerous images of the object source. This very phenomenon is raised as gravitational lensing [2].

- By unwavering research on the residual fragment of the emitted light rays that has been continuing from the very instance of the extreme sturdy spectacle, the Big Bang Cosmology, subsequently resulting into a stage of the Cosmic Microwave Background. The CMB standing for the Cosmic Microwave Background is the supreme impetuous generous theory corroborating the subsistence of the Big Bang Cosmological speculation in demonstrating the genesis of the cosmos. This  $\Lambda$ CDM model, where  $\Lambda$  is a Greek letter, symbolized for the Cosmological Constant which substantiates about a static cosmos, the idea of which being restrained in later epoch by Einstein, has been bestowed upon the theory of General Relativity that provokes it to be the accurate speculation of Einstein's Relativity, architecture upon gravitation in the perception of cosmological steadiness.

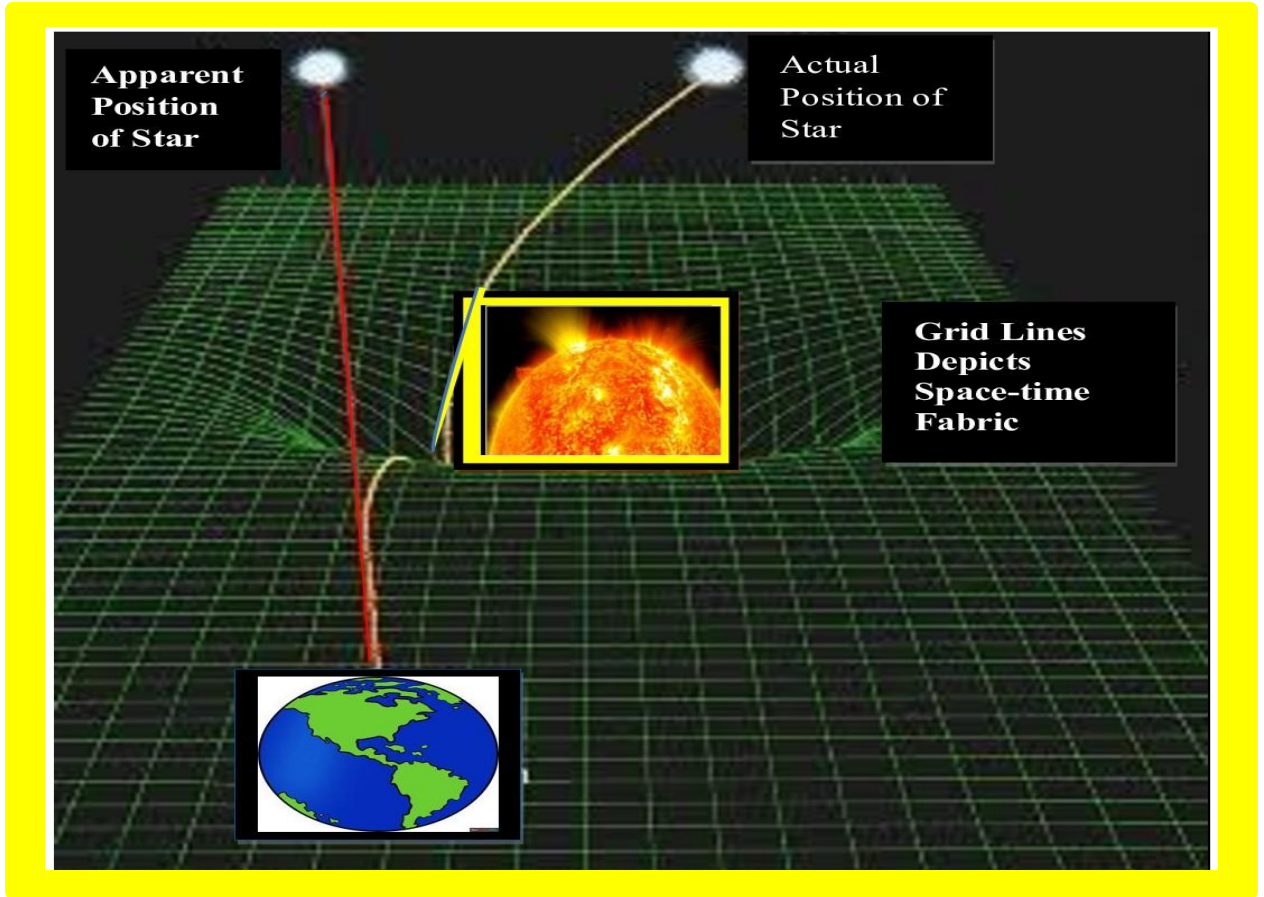


Figure 2

### 3.0 The Antiquity of Behind the Redshift Mechanism:

The 19<sup>th</sup> century remained as an endorsement eon for the exploration of redshift mechanism with the progression of the Classical Mechanics, premeditated on propagation of waves and eventually it got acquainted with Doppler effect technology. This effect has been nomenclature in the respect of the Austria based Mathematician, named Christian Doppler in 1842. According to Doppler, the very physics lying behind the mechanism could efficaciously be implemented on the phenomena related to some of the celestial entities like the stars where he got successful in breaking the boundaries that why colour alteration tactic got operational with the stars precisely which were attributed to the motion of the stars relative to the Earth [1].

The America based Astrophysicist named Vesto Melvin Slipher conducted the initial measurements of radial velocities exhibited by galaxies. He was the fundamental enunciator behind such experimentations to ascertain that distant galaxies are more redshifted, thereby delivering the first empirical foundation for the

extension of the universe [3], [4]. He additionally fundamentally interrelated such redshifts to velocity of the interstellar entities [5].

In the prior part of the twentieth century, Slipher, Wirtz and some other astronomers across the globe conducted the initial measurements of the redshifts and blueshifts of galaxies beyond the Milky Way. According to them, the functioning of the redshifts and blueshifts were on account of the random motions, which was later on clearly illustrated by Georges Lemaître, a Belgium based theoretical Physicist and Mathematician in the year 1927 and succeeding by Edwin Hubble in the year 1929, using previously endorsed data, ascertained an approximately linear correspondence between the increasing redshifts and distances. Edwin Hubble has made over 1.6 million observations of celestial objects including stars and galaxies. Georges Lemaître apprehended about such type of observations, those could be explicated by an arrangement of fabricating redshifts, perceived in Friedmann's solutions to Einstein's Field Equations of General Relativity. All cosmological models, the mechanism of correlation between redshifts and distances gets arises in all cosmological models signifying an escalated expansion of the cosmos.

Slipher testified the velocities for 15 spiral nebulae stretching across the cosmos where he found that three such nebulae have observable recessional i.e., positive velocities. At a later stage, Edwin Hubble postulated an approximated relation between the redshifts of such nebulae and their remoteness from an observer on Earth, with the formulation of his pulsating Hubble's Law. An America based astronomer named Milton La Salle Humason, worked with Edwin Hubble to measure the redshifts of nebulae in the early eon of 20<sup>th</sup> Century. These observations validated the research works of Alexander Friedmann in 1922 as when he derived the Friedmann-Lemaitre Equations. They are now establishing the strongest substantiation for the exponential expansion of the universe and the Big Bang Theory.

The name redshift was endorsed to be utilized by Arthur Eddington in 1923. In the subsequent years in 1934, William de Sitter who was a Dutch Mathematician, Physicist and Astronomer, utilized this term redshift in explaining his cosmological theory of modelling a universe which has been known after his name as de Sitter Model of the universe.

#### **4.0 Created Universe Intervening Redshift:**

The idea of a created universe can have different meanings depending on the religious beliefs or scientific perspectives. God created the universe, including the processes that led to the creation of galaxies, our solar system and life on Earth.

In a created universe, the word redshift gets conversant with the phenomenon of rapid expansion of the universe, which consequentially throws light on the point that as the universe is under the subsistence of exponential expansion, the light waves travelling through space stretched out, shifting the beam of light rays towards the red end of the spectrum, irrespective of the whether the universe had already been created or not. Here in this podium, the only functional mechanism is that the exponential expansion incurred in the cosmos by means of itself is the triggered driving force behind the experiential redshift [6].

#### **4.1 Vital Facts Concerning Redshift in a Created Universe:**

##### ➤ **Embedded Mechanism:**

The physical process of redshift, where light waves have been stretched apart due to the escalating expansion of the cosmos which remains identical in a created universe as in the case of a Big Bang Cosmological Model.

##### ➤ **Analytical Discrepancies:**

Although the underneath mechanism practicalized to be identical, however the rationalization of the tactic operational in the showground of redshift in a creationist view appear to diverge, it had been very potential pressurizing that the expansion incurred in the cosmos is an effectual upshot of the primary creation phenomena and not authentically rendered to a Big Bang cosmological phenomenon [6].

Potential considerations within a creationist perspective:

##### ➤ **Age of the Universe:**

In the limelight of some creationist perceptions proposition about an infantile universe that might be created during the much earlier epochs of the cosmos complemented with a significantly-hurried rate of inception expansion that has been prelude to explicate the experimental redshift while conferring to a succinct time dependent reference frame within which the considerably earlier cosmos was created.

##### ➤ **Working Out/ Fine-Tuning Proclamation:**

In the verdict of some Astrophysicists strong-arming the fact that the précised swifter expansion rate has been necessitous for the perceived redshift which is evidentiary for a premeditated universe.

#### **4.2 Experimental Evidences Accompanying with the Redshift Slant:**

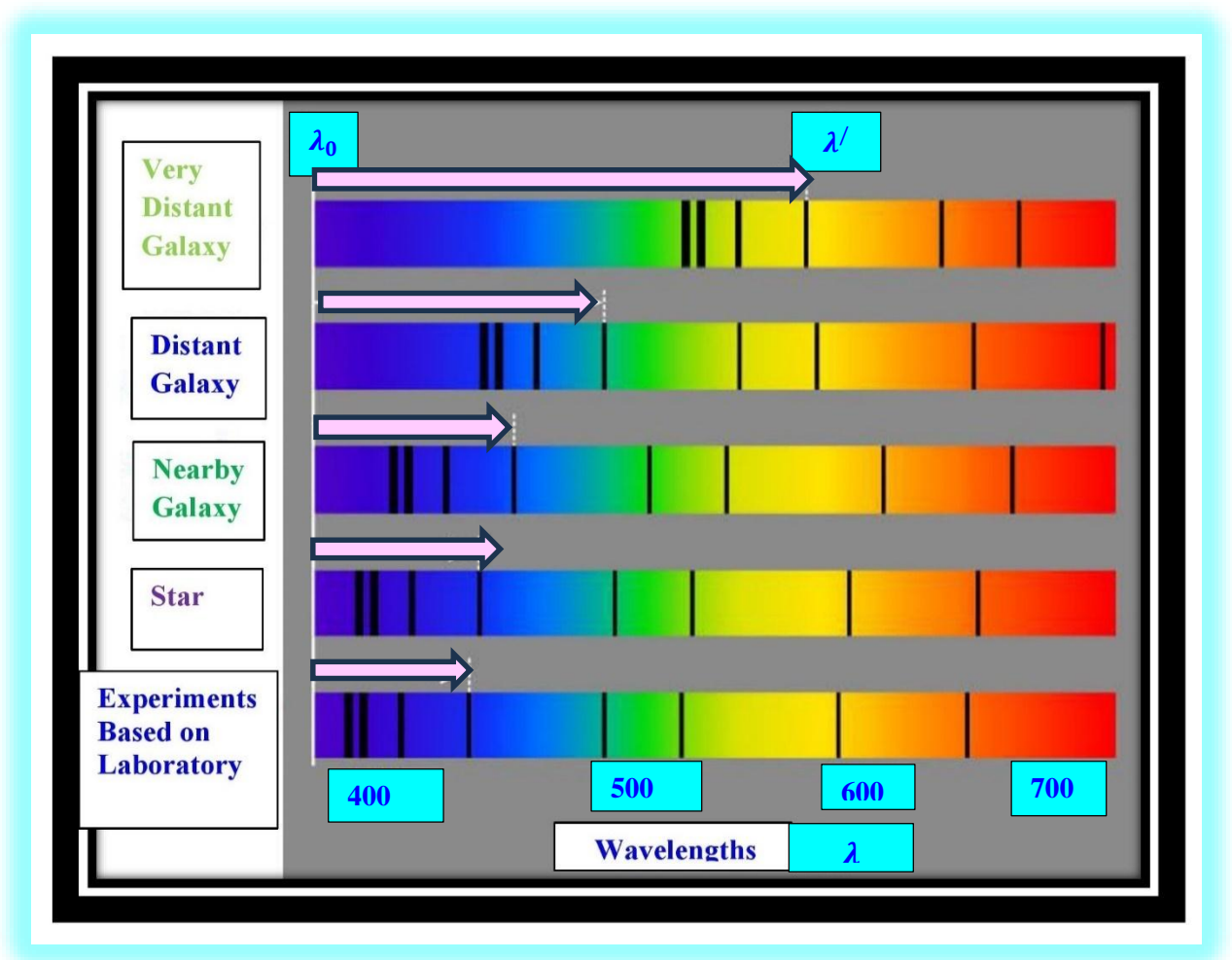
The red shift of a remotely co-ordinated celestial entity e.g., a far-flanged detached galaxy can be absolutely determined by making an assessment of its spectrum with a standard laboratory spectrum which can be supposed to be a reference one. Instances raise the illustrations of atomic emission and absorption lines that transpire at recognized wavelengths of the distinctive waves. Then a procedure of measuring the positional settings of such lines in astrophysical spectra, space scientists are capable of conceptualizing the redshift mechanism of the receding sources of light waves from the eyes of an observer residing on Earth.

#### **4.3 Here are a few pulsating facts regarding Redshift mechanism and Doppler Convention:**

The Doppler shifting technology apprehended in the frequency of light waves that has been emanated from far-flanged galaxies is one of the foremost sturdy sources of knowledge podiums of the universe [7].

➤ For an extreme accurate numerical measure, it is to be evident that the red shifts acclimatized in remotely detached celestial entities are not precisely functioned/ ascribable to the influence of Doppler effects, conversely are rather than a consequence of the hurried expansion of the cosmos in every permissible direction [8].

- The Shifting of the light rays due to Doppler tactics arise from the rational motion of the light source and an observer on Earth through the interstellar medium of space, while some supplementary theory affirms that the observed astronomical redshifts are primarily due to the expansion of redshifts which are attributed to the spreading out of the cosmos itself.
- Two celestial objects practically can be static or at a standstill position in space and in spite of this motionless tactic, they encompass red shift phenomenon if the intermediate space itself which has been intervening between these two interstellar objects is experiencing an escalating expansion.



**Fig. 3:** Depicting Wavelength Fluctuations for Different Celestial Objects

**Picture Courtesy:** Citation [9]

In the above Fig.3, it has been visualized that the pattern or layout of the visible vertical lines of the light rays emitted by the various sources like galaxies, stars etc., having very negligible widths, remains the same however they are just shifted to the

longer wavelengths or the red bands of the spectrums, essentially signifying the mere ascendancy of the redshift speculation.

When a beam light rays traverses through the cosmos, the wavelengths of the photon particles are stretched as the universe is under the privilege of exponential expansion. Let us denote this wavelength that has been measured on Earth by the notation,  $\lambda_{Obs}$  which is presumed to be grander than the original emitted wavelength  $\lambda_{em}$ . These wavelengths have been connected by the relation

$$\frac{\lambda_{Obs}}{\lambda_{em}} = 1 + z = \frac{a_0(t)}{a}$$

The scale factor of the universe as measured today is  $a_0(t) = 1$ . From the above formula, the redshift  $z$  can be calculated and subsequently, the scale factor  $a$  of the universe after substituting all the known quantities in their respective places and then simplifying.

#### 4.4 Motion Fluctuating the Wavelength of Light Waves:

It has been experiential that when a shiny and lustrous celestial object such as a star or a flashlight is approaching towards an observer on Earth, the wavelength of the emitted light suffers curtailing effects and will suffer shifting towards the blue end of the spectral band. On the other hand, if the source of light is moving away from an observer on Earth, the wavelength of light emitted gets elongated and henceforward gets red or shifted towards the red band of the spectrum. This happens due to the surveillance of Doppler Effect of light [9].

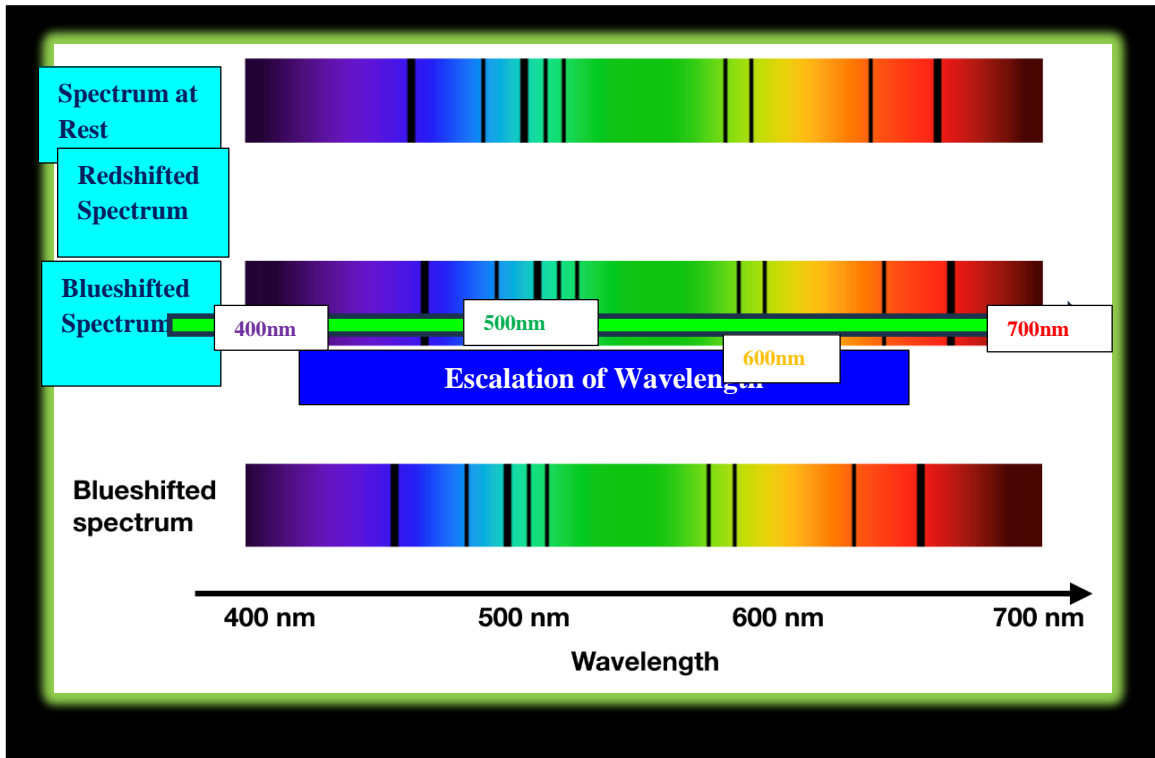


Fig. 4: Depicting the differences between Redshifted and Blueshifted Spectrum

In the above Fig. 4, as the wavelength of the light rays gets widened/ stretched due to the expansion of the universe which is due to the ascendancy of dark energy, the effect on the light emitted by the shiny object suffers blueshift and redshift accordingly as explained above and can be visualized in the Fig 4, where the phenomena of redshift and blueshift have been depicted in the second and third rows of the light bands or the spectrums respectively [10].

**4.5 Amalgamation of Redshift Data with Hubble’s Techniques:**

The revolutionary fact pertaining to the preliminary idea of an expanding universe is that the more detached away a galaxy is, the higher its light is redshifted. This very mechanism perceived on applying the techniques of distance measurements of Hubble in the year 1917 [1]. It has been credited to Vesto Slipher, the first person to discover galactic redshifts in about 1912 [1]. In the year 1929, Edwin Hubble discovered that the furthestmost galaxies experienced redshifts.

The following Table 1 essentially presenting a cosmological scenario showing detachments measured in light years with the help of Edwin Hubble’s space telescope and application of Hubble’s Law in correspondence to the conceivable redshift data.

**Table 1**

Sl. No.	Cluster Nebula Apprehended in Constellations/ Zodiac Sign	Distance Traversed in Light Years	Redshifted Data
1	Virgo Zodiac Sign	78,000,000	1200 km $sec^{-1}$
2	Ursa Major Constellation	1,000,000,000	15,000 km $sec^{-1}$
3	Corona Borealis Constellation in the Northern Celestial Hemisphere	1,400,000,000	22,000 km $sec^{-1}$
4	Bootes or Herdsman Constellation in the Northern sky	2,500,000,000	39,000 km $sec^{-1}$
5	Hydra Constellation or Sea Serpent, a large and faint constellation in the Southern sky.	3,960,000,000	61,000 km $sec^{-1}$

**Table Data Courtesy:** Vesto Slipher at Lowell Observatory, Galactic Redshifts in 1917

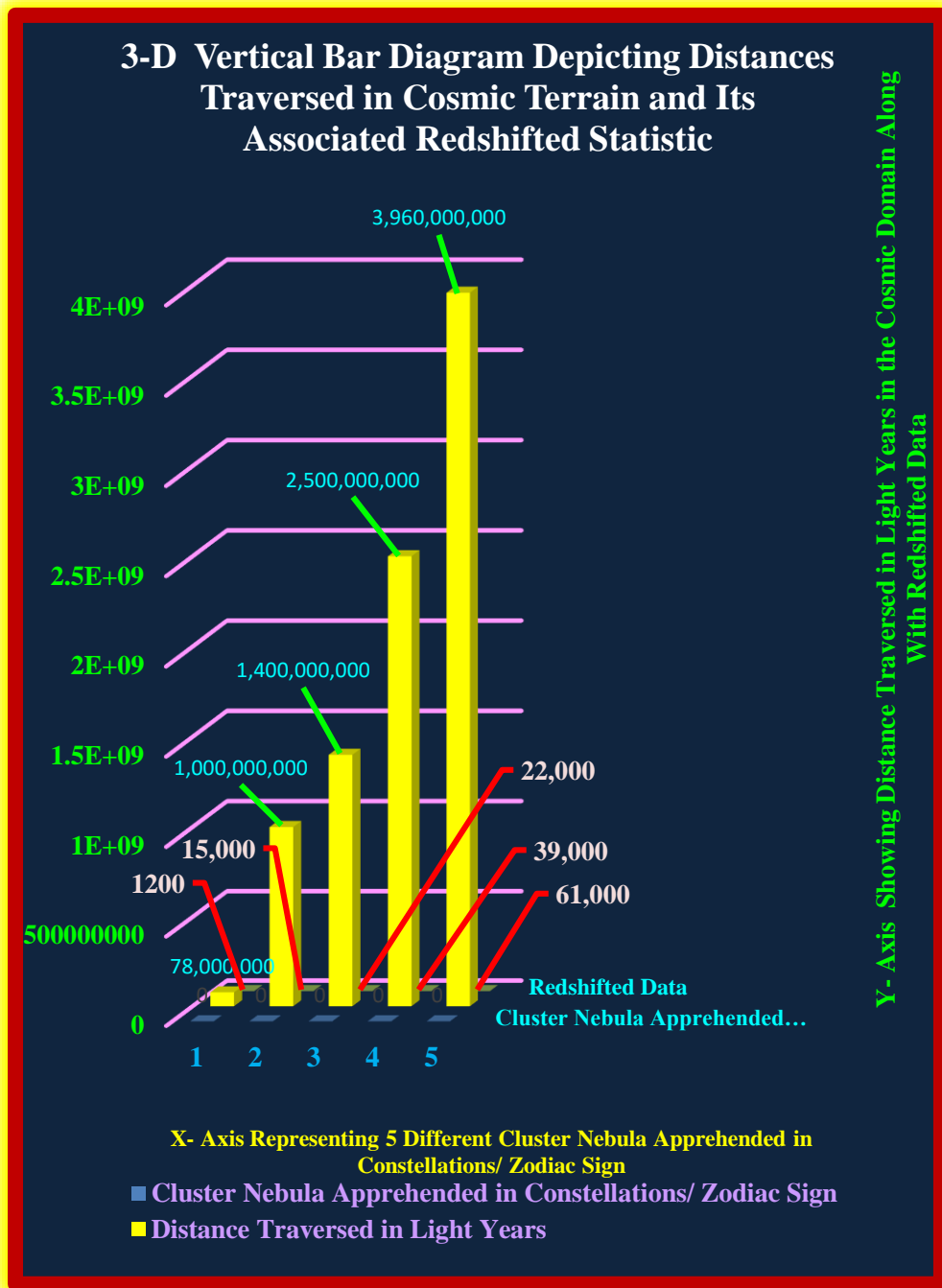


Fig. 5

**5.0 Computational Redshift Mechanism Aggrandized by Doppler/ Relativistic Doppler Effect Illustration:**

If a source of the light is moving away from an observer on Earth, the redshift which is usually denoted by  $z > 0$  hold good. If the source moves towards the observer, then blueshift i.e.,  $z < 0$  prevails. These restraints have been proven accurate for all

electromagnetic waves and is enlightened by Doppler Effect. Such redshift has been denoted by Doppler redshift. If the source moves away from the observer with a velocity  $v$  with the property that  $v \ll c$ , where  $c$  is the speed of light waves in vacuum and it has a value,  $c \cong 3 \times 10^8$  metre/sec for which the redshift is usually given by

$$z \approx \frac{v}{c}, \because \gamma \approx 1$$

An additional comprehensive endeavour of the Doppler redshift necessitates deliberating the relativistic upshots accompanying with motion of celestial objects near to the speed of light waves. A complete derivation of this effect can be found in the section pertaining the Relativistic Doppler Effect. Summarising in a compact manner, the celestial objects moving near to the speed of light waves will practice unconventionalities from the above formula due to the extension of time of Special Relativity that can be modified for by familiarizing the Lorentz Factor, denoted by  $\gamma$  into the classical Doppler formula as follows:

$$1 + z = \left(1 + \frac{v}{c}\right) \cdot \gamma$$

This phenomenon was first experiential in an experiment performed by Herbert E. Ives and G.R. Stilwell, called the Ives Stilwell Experiment [11] in the year 1938.

Since the Lorentz factor is reliant solely on the magnitude of the velocity, this can be the cause of the redshift mechanism connected in the relativistic correction to be independent of the orientation of the movement of the source of light in the cosmological terrain. In a divergence tactic, the classical fragment of the formula is reliant on the projection of the movement of the source into the line of vision which conforms to diverse outcomes for distinct co-ordination. If  $\theta$  is the angle between the direction of comparative motion and the direction of emission in the observer's frame [12] in which zero angle is straightforwardly apart from an observer on Earth, the full arrangement for the relativistic Doppler effect turn out to be:

$$1 + z = \frac{1 + v \cos \frac{\theta}{c}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

and for a motion exclusively conceiving in the line of sight ( $\theta = 0^\circ$ ), the equation diminishes to the following formula:

$$1 + z = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}}$$

For the special case that the light wave has been moving at right angle ( $\theta = 90^\circ$ ) to the direction of comparative motion in the observer's frame of reference [13], under such scenario, the relativistic redshift is termed as the transverse redshift:

$$1 + z = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

A redshift is measured, in spite of that still the cosmological object is not moving away or detaching from the observer on Earth. Additionally, when the source of light

waves is approaching towards the observer, there subsists a transverse constituent to the motion then there exists approximately some speeds at which the dilation appropriately strikes down the expected blueshift and at greater speed, the forthcoming light source will be on the status of redshifted [14].

**6.0 The Assemblages Concerning Redshift Mechanism with Doppler Effect:**

The motion of celestial objects can be ascertained by observing the spectra. Under the surveillance of the Doppler Effect techniques, celestial objects approaching towards are blue shifted whereas those objects drawing back are redshifted. This has been the vital key technique regarding the motion of an interstellar body and in sketching a scenario of redshift mechanism whose central mechanism is identical to the tactic of Doppler Effect. It has been observed that the wavelength of redshifted light is stretched, come into sight as redder/ reddish than the light source. Contrariwise, the wavelength of the blue shifted light is shorter, visibly bluer than the light source. Thus, we shall have the relation

$$\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v_0}{c}$$

In the above equation,  $\lambda$  is the observed wavelength and  $\lambda_0$  is the emitted wavelength of light rays,  $v_0$  is the velocity of propagation of the interstellar object. It has been found that when  $v < 0$  which corresponds to  $\lambda < \lambda_0$ , eventually signifying a blue shifted wavelength. A red-shifted absorption or emission line will look as if approaches more towards the red band of the spectrum while comparing to a stationary line. The generalized Hubble Law can be made functional under such scenario which is

$$v = H_0 d$$

Where  $v$  is the recession velocity,  $H_0$  is the Hubble Constant and  $d$  is the distance of the celestial object from the Earth.

Redshift ( $z$ ) can be expressed by the following equations:

**Formulae for the Calculation of Redshift,  $z$**

**Table 2**

<b>Formulae Centred on Wavelength</b>	<b>Formulae Centred on Frequency</b>
$z = \frac{\lambda_{Obs} - \lambda_{em}}{\lambda_{em}}$	$z = \frac{f_{em} - f_{Obs}}{f_{Obs}}$
$1 + z = \frac{\lambda_{Obs}}{\lambda_{em}}$	$1 + z = \frac{f_{em}}{f_{Obs}}$

Here in this above Table 2, depicting the formulae for computation of redshift  $z$ ,  $f$  is the frequency and  $\lambda$  is the wavelength. The larger the value of  $z$ , the more redshifted the light spectrum and the object is moving exceedingly away from the Earth. In January 2013, observations entail the data regarding the largest galaxy redshift, practicable is of  $z \sim 12$  was achievable using the Hubble Ultra-Deep Field which is an image representing the deepest view of the observable cosmos ever captured that

visualizes thousands of galaxies from several stages of the evolutionary manifestos of the universe, conforming to an age of the conceivable universe that exceeds 13 billion years precisely predicting the universe to be roughly 13.82 billion years old. [15], [16], [17], [18].

The Doppler Effect and Hubble's law can be amalgamated that construct the following equation  $z = \frac{v_{Hubble}}{c}$ , where  $c$  is the speed of light waves in vacuum.

The Table 3 below depicts the travelling times of light waves and the remoteness attained for some redshifted (sample) values of  $z$ :

**Table 3**

Sl. No.	Calculated value of $z$	Time of Traversal of the Light Waves	Detachment Attained in Space by Some Celestial Objects
1	0.0000715	1 Million Years	1 Million Light Years
2	0.10	1286 Billion Years	1349 Billion Light Years
3	0.25	2916 Billion Years	3260 Billion Light Years
4	0.5	5019 Billion Years	5936 Billion Light Years
5	1	7731 Billion Years	10,147 Billion Light Years
6	2	10,324 Billion Years	15,424 Billion Light Years
7	3	11,476 Billion Years	18,594 Billion Light Years
8	4	12,094 Billion Years	20,745 Billion Light Years
9	5	12,469 Billion Years	22,322 Billion Light Years
10	6	12,716 Billion Years	23,542 Billion Light Years
11	7	12,888 Billion Years	24,521 Billion Light Years
12	8	13,014 Billion Years	25,329 Billion Light Years
13	9	13,110 Billion Years	26,011 Billion Light Years
14	10	13,184 Billion Years	26,596 Billion Light Years

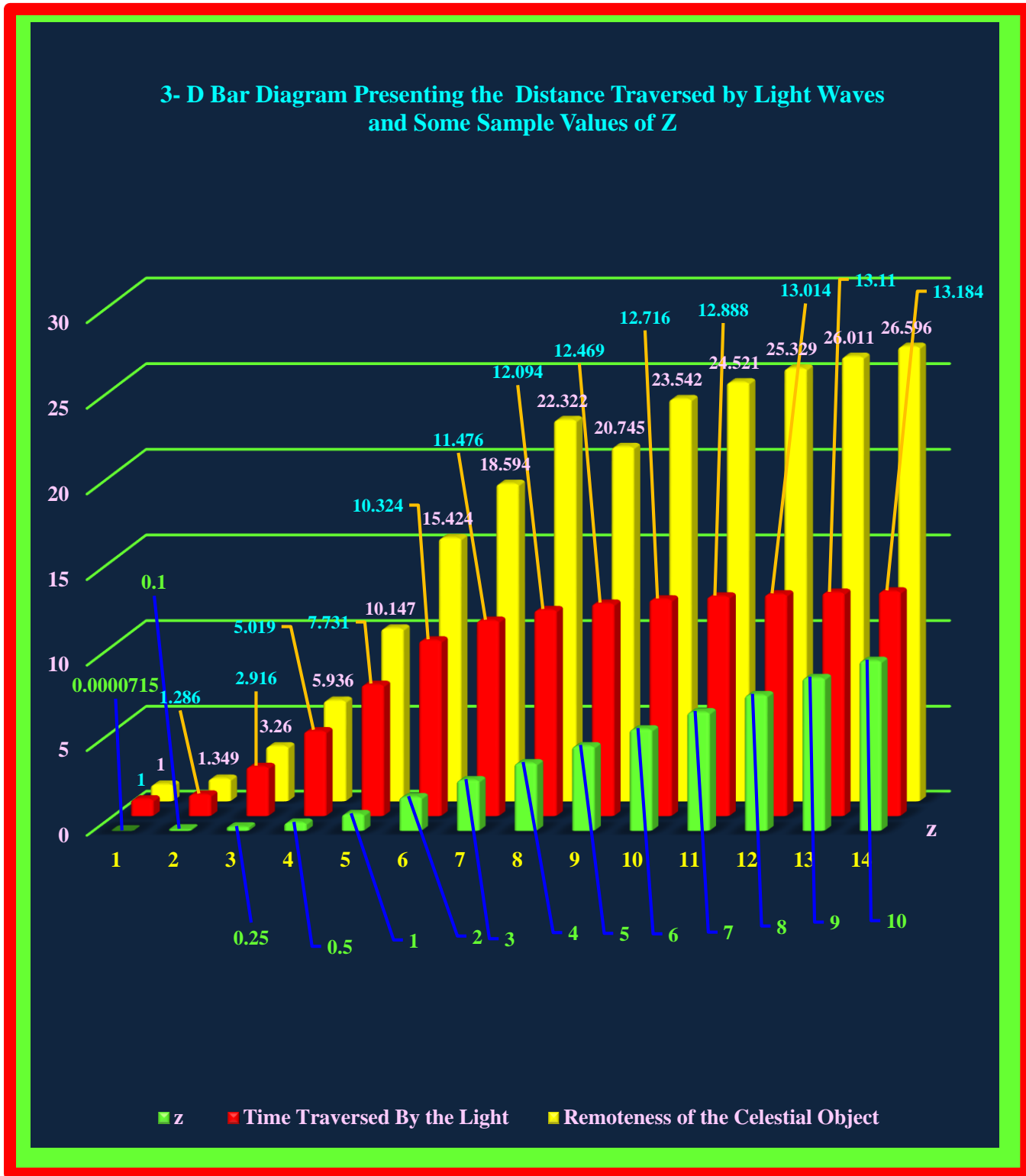


Figure 7: With 3-D Vertical Column Representation.

**Table Data Courtesy: NASA/ESA**

**7.0 Visualizing Cosmic expansion:**

The explanations incurring growing redshifts from further and further detached galaxies can be modelled presumptuously a homogeneous and isotropic universe united with General Relativity. This cosmological redshift can be inscribed as a function of the cosmic scale factor  $a$ , which is a function of time  $t$  [19]. This has the representation:

$$1+z = \frac{a_{now}}{a_{then}} = \frac{a_0}{a(t)}$$

Since  $t$  approaches infinity and  $t \rightarrow \infty$ , the redshift, denoted by  $z \rightarrow 0$  and experiences an intensifying measure for aloof galaxies which emerges to be redshifted.

Using a model of the expansion of the universe, redshift can be correlated with the age of an observed celestial object, the perceived cosmological time-redshift relation. Denote a density ratio as  $\Omega_0$ :

$$\Omega_0 = \frac{\rho}{\rho_{crit}}$$

where  $\rho$  is the density of the cosmic fluid,  $\rho_{crit}$  is the critical density and  $\Omega_0$ , essentially denotes a density ratio.  $\rho_{crit}$  stands for the critical density establishing a universe that in the end suffer colossal crunches from that purely magnifies. This density is about three hydrogen atoms per cubic meter of space [20].

At large redshifts,  $1 + z > \frac{1}{\Omega_0}$ , it has been achievable that:

$$t(z) \approx \frac{2}{3H_0\Omega_0^{\frac{1}{2}}} \cdot z^{-\frac{3}{2}}$$

where  $H_0$  represents the value of the Hubble Constant [21], [22].

The cosmological redshift is normally attributed to elongation of the wavelengths of photons due to the spreading out of space. The cosmological redshift can be construed as an amalgamation of negligible/ inconsiderable Doppler shifts all along the trajectory of the light waves [23].

**7.1 Formula for Cosmological Redshift:**

The formula entails

$$z = \frac{\Delta\lambda}{\lambda} = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}} - 1$$

where the terms have their usual meanings.

**8.0 Illustrating Gravitational Redshift:**

Gravitational redshift is the phenomenon in which light waves suffer shifting towards the red end of the spectrum as it moves away from a colossal celestial object. This transpires since light rays dissipates energy as it ascends out of a gravitational field. Such dissipation of energy be consistent to a decline in the frequency and increase in the wavelength of light waves emanated from a light source of the cosmos.

**8.1 Explanation:**

- Albert Einstein's General relativity envisages the gravitational redshift
- In General Relativity, gravity is an architecture of spacetime curvature merely fabricated by the sturdy presence of mass and energy in space.
- The curvature of spacetime influences the path or trajectory of the light rays.

### **8.2 Applications:**

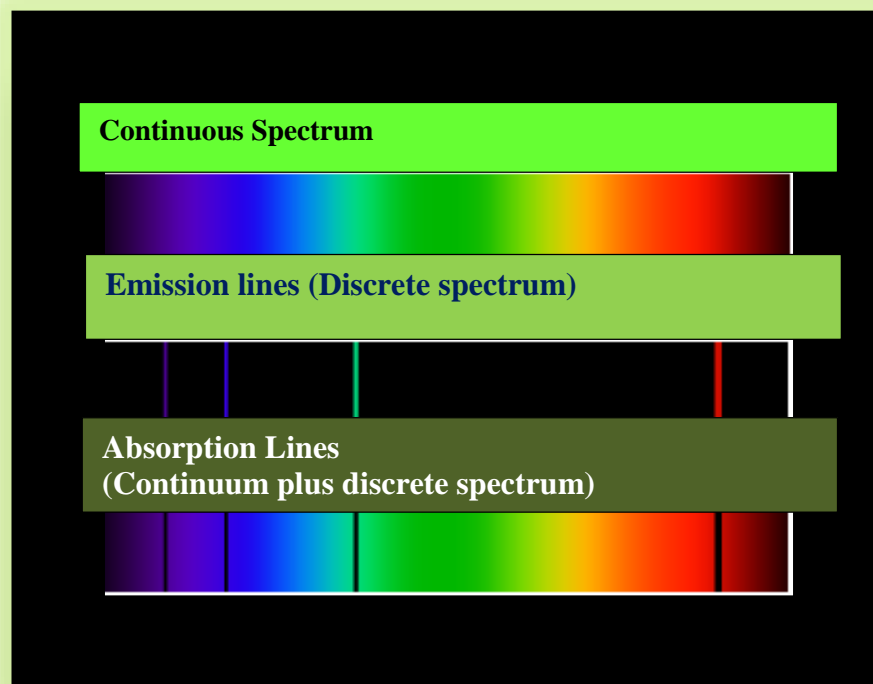
- Gravitational redshift helps to predict the possessions of gravity on light waves and the cosmic ambience.
- Gravitational redshift has been utilized to measure the mass of white dwarf stars, such as Sirius B.

### 9.0 Introducing Spectroscopy as an Effectual Measure of Redshift:

Spectroscopy is the branch of analytical Physics that relates to the analysis of the absorption and emission description history of the light waves and additionally other radiation log due to matter [24]. It involves the splitting up of the electromagnetic radiation such as light waves into its component wavelengths, constituting a spectrum, in the similar manner as a prism splits light into the seven colours of a rainbow. In earlier times, spectroscopy was portrayed or operational using a prism and photographic plates.

Among the various branches of Spectroscopy, Astronomical Spectroscopy is predominantly be connected with the analysis of celestial objects. Initiating from the most generous spectroscopic investigation connected to a celestial object, the measurement of the mostly précised spectrum of electromagnetic radiation and an establishment of the corresponding wavelengths has to be executed. This entails the data regarding the chemical composition of the celestial object as an aspect of their spectral bands and masses, temperatures, remoteness and speeds with the usage of a function of the wavelengths of emitted light waves and the speed of light waves [24].

The most provoked appropriate technique for measuring redshift is by efficacious adoption of the techniques embedded in Spectroscopy. When a transparent beam of white light rays hits a triangular prism, this beam suffers diffraction and consequentially been separated into its various constituent colours of the light band, known as a spectrum. At this step, the astrophysicists have to play the most apprehended role to investigate the spectra formed by the constituents and assess or judge against these spectra with the spectra of stars. If the absorption or emission lines can be viewed in the spectra of the stars and are found to be shifted, it can be evidenced whether the interstellar object is moving towards or detaching away from an observer on earth.



**Fig 8**

**(Depiction of Continuous, Discrete and Amalgamation of Continuum & Discrete Spectrum)**

- In the Continuous Spectrum Section, the spectral band of the light rays is being flawlessly emitted and evenly dispersed.
- In the second spectral ray bands, the emission of coloured light ray bands has been represented by some distinct coloured vertical ray bands of smaller widths.
- In the third spectral ray bands, the different colours of the spectrum get absorbed in the feasible portion of the spectrum and these colours get assimilated and dispersed behind the vertical black coloured line spectrums and eventually forming a homogeneously disseminated spectral ray bands in the visible portion of the spectrum.

The subject arena named Astronomical Spectroscopy has its utilization in experimenting the vivid physical characteristics of numerous celestial objects. Examples include galaxies or cluster of galaxies, nebulae, planets, stars and additionally active galactic nuclei and so on [25].

The following Table 4, emission spectra of the different types of gases available in the Sun's spectrum has been visualized. The technology of Spectroscopy is applied which deploys a vital role by making a comparison of the absorption lines of the Sun with

recorded emission spectra of the previously familiarized gases, the chemical composition of the celestial bodies such as the stars can be ascertained.

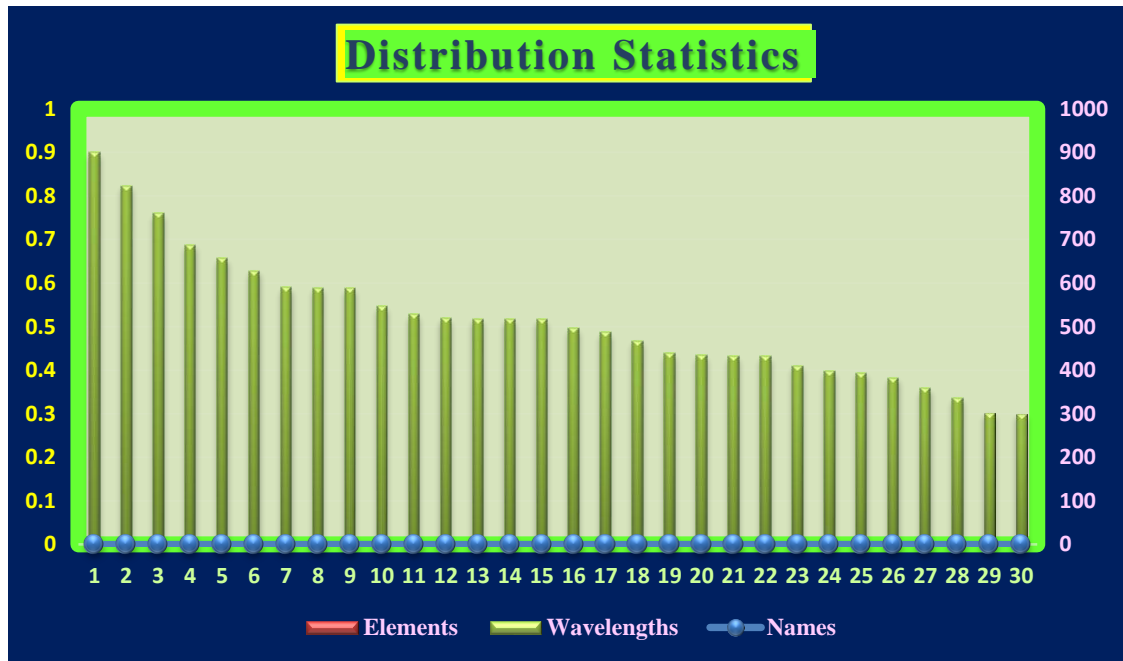
**Table 4**

Sl. No.	Designation	Elements	Wavelengths
1	y	O <sub>2</sub>	898.765
2	Z	O <sub>2</sub>	822.696
3	A	O <sub>2</sub>	759.370
4	B	O <sub>2</sub>	686.719
5	C (H $\alpha$ )	H	656.281
6	a	O <sub>2</sub>	627.661
7	D <sub>1</sub>	Na	588.995
8	D <sub>1</sub>	Na	587.5618
9	D <sub>3</sub> or d	He	546.073
10	e	Hg	527.039
11	E <sub>2</sub>	Fe	518.362
12	b <sub>1</sub>	Mg	517.270
13	b <sub>2</sub>	Mg	516.891
14	b <sub>3</sub>	Fe	516.733
15	b <sub>4</sub>	H	495.761
16	c	Fe	486.134
17	F (H $\beta$ )	Fe	466.814
18	d	H	438.355
19	e	Fe	434.047
20	G' (H $\gamma$ )	H	430.790
21	G	Fe	430.774
22	G	Ca	410.175
23	h (H $\delta$ )	H	396.847
24	H	Ca <sup>+</sup>	393.368
25	K	Ca <sup>+</sup>	382.044
26	L	Fe	358.121
27	N	Fe	358.121
28	P	Ti <sup>+</sup>	358.121
29	T	Fe	302.108
30	t	Ni	299.444

**Table Data Courtesy:** NASA/ESA

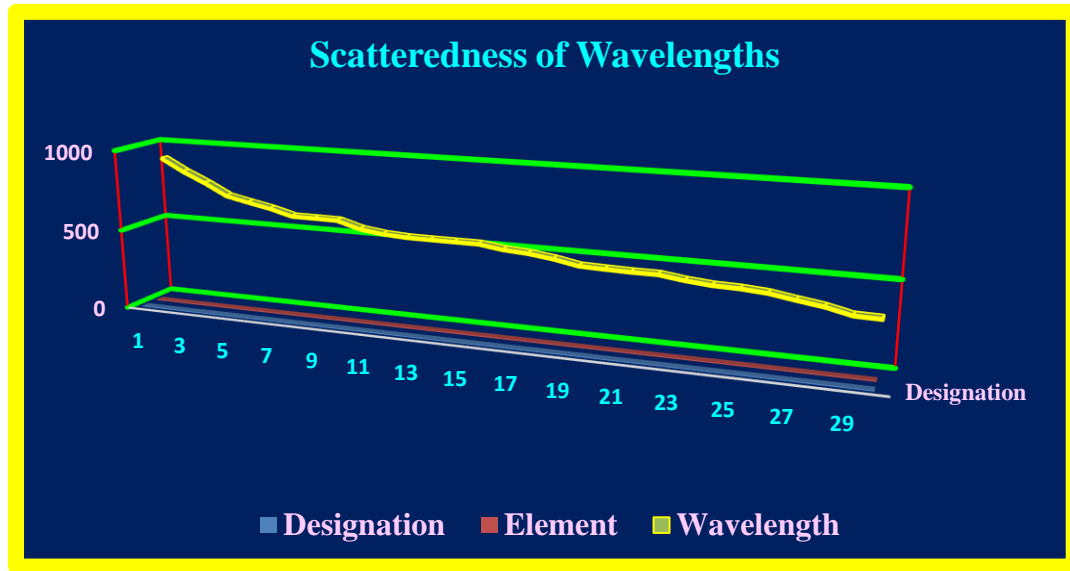
In the above Tabular distribution representation of wavelengths of lights emitted by different elements which have also different names/ labels/ designations for each of the corresponding elements of the Fraunhofer lines, earlier some of the elements of the series were analyzed and portrayed in Balmer series and the labels of the common elements have been depicted by enclosing these within a pair of parentheses. The unit for representing wavelength is nm stands for nanometre and usually used for visible spectrum of light waves, where 1 nm = 1 billionth of a metre.

Fraunhofer lines are dark absorption lines in the sun’s spectrum that are caused by the selective absorption of light by the elements present in the Sun’s ambience. The blisteringly hot outermost corona segment of the Sun’s atmosphere, contains gaseous elements that absorb certain wavelengths of light. The shifting of wavelengths describes the motion of gases. Approximately 25,000 Fraunhofer lines are found to exist in the solar spectrum [25].



**Fig. 9**  
**Bar Diagram Representation 2**  
**(As Discrete Vertical Columns)**

In the above Table 3, the data flourishing the different plausible representations of the spectral lines as depicted by the German physicist Joseph V. Fraunhofer for which he plotted more than 500 lines of the Sun’s spectra and designated the most luminous among them by the letter of the English Alphabet from A to Z [26].



**Fig. 10**  
**(Graphical Representation)**  
**(As 3-D Line Representation)**

### 10.0 Applications of Redshift in Sketching Precisely Vivid Scenario of the Cosmos:

Astrophysicists and space scientists have been precisely hinging on the shifting mechanism viz., the redshift and blue shift phenomena to throw light on the terrestrial objects like the stars and planets observed beyond the Solar System and the technique deployed in this tactic is known as the radial velocity method.

This mechanism has been based on the fact that if a star is encompassed with planet or a system of planets in its most nearby ambience, it is not stringently accurate to predict that the planet orbits round the star. In its situation, the planet and the star practically orbit their common centre of mass. Since the star is more gigantic in comparison to the planets, the centre of mass is centred within the star and the star seems to oscillate to an insignificantly little extent as the planet moves around it. An astronomer can become capable of measuring such quivering effect by employing spectroscopy.

From the very mechanism of redshift, it has been evident that if a star is approaching towards us, the light will give the effect of blue shifted and if the light seems to be moving apart, consequently the beam of light rays will be redshifted. This shifting towards the red or the left band of the spectrum, is not practically possible to be viewed without using terrestrial telescopes. The technique of Spectroscopy has been implemented to perceive this transformation in colour as the star or any other stellar object moves towards or away from an observer on Earth, orbiting the centre of mass of the star-planet coupled system.

This very terminology is applied in case of the binary stars which are experientially observed to be orbiting each other, the rotational motion experienced by the galaxies or the movements of cluster of galaxies, motion of the stars or any other celestial entities within or beyond the Solar System.

The concept of Created Universe in connection to redshift mechanism is basically grounded on the mechanism that supersedes the created universe ideology that has been bestowed upon the mythological belief that some sturdily preferred colossally massive, superficial power source has been enacting upon the laws and governance of the movements/ motions of the exceedingly stretching apart celestial entities towards the red band of the spectrum rather than the physics of space entails the realistic and observed cosmological perspective that the light rays gets intensified more towards the red band of the spectrum purely due to the exponential expansion incurred in the universe because of the abundancy of dark energy in this present dark energy dominant epoch which has been continuing after the matter dominated epoch that has been following after the radiation dominated era of the universe.

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