Some Criteria for Short-listing the Cosmological Red-Shift's Explanations

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Abstract:

Louis Marmet, in a paper titled: "On the Interpretation of Red-Shifts: A quantitative comparison of red-shift mechanisms-II" Dated 4th December 2014, [1] has briefly compiled around 59 candidate mechanisms, including the standard Big Bang Cosmology, attempting to explain the observation of the 'cosmological red-shift'. This paper proposes some criteria for short-listing the most likely explanations; and adds some more explanations to the list. The need for considering alternative mechanisms arises because the Big Bang cosmology is based on the assumption of homogeneity and isotropy of space at 100 M pc scale, for the explanation of the 'cosmological red-shift', whereas linear Hubble law is observed even at 1 M pc distances, where distribution of matter and energy is clearly not homogeneous. And Big Bang Cosmology demands 95 % 'dark-energy' which is not yet found. Alternative explanations for 'cosmological red-shift' are rejected under a pre-text that they are not compatible with the observation of 'time-dilation of super novae light-curves'; but a paper by Tank, titled "Wave-theoretical insight into the Relativistic Length-contraction and Time-dilation of Super novae Light-curves" [2] has shown that any mechanism which can cause 'cosmological red-shift' will also cause 'time-dilation of super novae light-curves', so every possible mechanism needs to be considered without any bias. The criteria for short-listing proposed here is: that the loss in energy of cosmologically red-shifting photon is proportional to the strength-ratio of gravitational and electric forces ($G\ m_e\ m_p\ /\ e^2$), which suggests that the energy of inter-galactic photon seems to get branched-out into gravitational and electrostatic potential-energy parts, and gravitational potential-energy-part is getting subtracted from the energy of the photons.

Key Words: Cosmology, Cosmological red-shift, Cosmic gravitational force, Pioneer anomaly.

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1. Introduction:

The Big Bang Cosmology demands 95 % 'dark-energy' which is yet to be found. Just as no lady would marry a man who says that he is yet to earn money, so exactly, true scientists can take the 'expansion of space' to be correct only after the 'dark-energy' gets detected. Secondly, the FLRW model of cosmology, commonly known as Big Bang Cosmology, is based on the assumption of homogeneity and isotropy of space at 100 M pc scale, for the explanation of the 'cosmological red-shift', whereas linear Hubble law is observed even at 1 M pc distances, where distribution of matter and energy is clearly not homogeneous. So this theory should explain the linear Hubble law within the 1 M pc distance-scale, within a galaxy. Moreover, The general relativity theory predicts 'expansion of space' between the galaxies; but the space within the galaxy is not expanding, because galaxy is a gravitationally-bound-structure. The question raised here is: If so, then what happens at the edge of a galaxy whose external space is expanding but the space within is not expanding? Is there a smooth transition from expanding to non-expanding space? If expanding-space can stretch the wavelength of a cosmologically red-shifting photon, then less and less expanding space, at the boundary of the galaxy, should shrink the wavelength back to its original length, isn't it ? Moreover, it is currently believed that the expansion of the universe is accelerating at the rate $H_0\ c$, whereas the following derivation shows that it is the photon which is decelerating at the rate $H_0\ c$, as shown below: The linear part of the cosmological red-shift is expressed as:

$$(z_c) = (h f_0 - h f) / (h f) = H_0 D / c$$

i.e. $$(h f_0 - h f) = (h f / c^2) (H_0\ c) D .$$

That is: the loss in energy of a cosmologically red-shifting photon is its mass ($h f / c^2$) times the deceleration ($H_0 c$) times the luminosity-distance D. Whether the expansion of the universe is accelerating is still a hypothesis; whereas intergalactic photon decelerates at the rate ($H_0 c$) is a consistently observed fact! Therefore, there is a need for considering alternative explanations for the 'cosmological red-shift'.

2. The Criteria:

Prior to that some preparatory discussion: P.A.M. Dirac, after receiving the Nobel Prize, when he was on world tour, he got an idea, that: We measure physical quantities in arbitrarily chosen units like: meter, kilogram and seconds. We should use some standard physical length, like the 'classical radius of an electron' (r_e) , to measure lengths. As soon as he expressed the 'radius of the universe' R_0 in terms of

'radius of an electron', to his pleasant surprise the ratio (R_0 / r_e) turned out to be equal to the ratio $(e^2/ G\, m_e\, m_p) = 10^{40}$. And Eddington found that the ratio $(M_0 / m_p) = (e^2/ G\, m_e\, m_p)^2 = 10^{80}$; here M_0 is 'total mass of the universe' and m_p is mass of a proton. Though Dirac's 'Large Number Hypothesis', predicting reduction of 'strength of gravity' with age of the universe, did not match with observations. But the numerology of the above 'Large Number Coincidence' has been striking. Later in 1997 this writer showed that this coincidence implies that: Mass of the universe is equal to gravitational potential-energy of the universe; and electro-static potential-energy stored in an electron is equal to energy of mass of it [3]. We intend to use here the 'large-number-coincidence' (LNC), (not the large-number-hypothesis predicting reduction of strength of gravity with time LNH) to reach an interesting conclusion.

Similarly Max Planck tried to derive natural units, of mass, length and time, purely from the fundamental physical constants; but Planck's unit of mass did not match with mass of any physically observed particle. Later this writer showed [4] that Planck's unit of mass is 'geometric mean value' of two different masses, namely 'total mass of the universe' M_0 and smallest conceivable mass $(h\, H_0 / c^2)$; and similarly Planck's length, $L^* = [(G\, m / c^2)\, (h / m\, c)]^{1/2}$, that is Planck's length is a geometric-mean of gravitational-radius and Compton-wavelength of every particle. [It may be interesting to see that: just as the 'fine-structure-constant' $(e^2/ h\, c) = (m_e / m_{pion})$, the ratio $[(G\, m_e\, m_{proton})/ (e^2)] = [(h\, H_0 /c^2) / m_e)]$, so the mass $(h\, H_0 / c^2)$ seems to be of significance.]
Following the line of thinking of Planck, Steven Weinberg tried to derive a fundamental unit of mass by taking four different fundamental constants, including H_0 , and got a value of mass quite close to the mass of a fundamental particle [5]. He found that:

$m_p^3 = h^2\, H_0 / c\, G$ ……………………………….(1)

Here H_0 is Hubble's constant. And the value of mass m_p turned out to be close to the mass of a fundamental-particle, pi meson. Alternatively, m_p^3 can be viewed as $m_{proton} \cdot m_{proton} \cdot m_{electron}$. Weinberg's relation can be written in a meaningful manner as:

$G\, m_p^2 / (h / m_p\, c) = h\, H_0$ ……………………..(2)

Where $(h / m_p\, c)$ can be taken as a 'fundamental-unit of length'; and the quantity $h\, H_0$ as the 'smallest chunk of energy'.

Based on the above preparatory discussion, we can now re-consider the 'cosmological red-shift'.

(i)

The linear part of the 'cosmological red-shift' is expressed as:

$z_c = (\Delta \lambda / \lambda_0) = (H_0 D / c)$ …..……(3)

The right-hand-side of expression-3 can be written as:

$H_0 D / c = h H_0 / (h c / D)$ ……..(4)

Based on Weinberg's relation: $m_p^3 = h^2 H_0 / c G$, which we have re-written in a meaningful manner as: $[(G m_p^2) / (h / m_p c)] = (h H_0)$, the 'cosmological red-shift' can be expressed as:

$z_c = \Delta \lambda / \lambda_0$

$= [G m_p^2 / (h / m_p c)] / [h c / D]$.....(5)

i.e. $z_c = \Delta \lambda / \lambda_0$

$= [G m_p^2 / h c] [D / (h / m_p c)]$ …...…...(6)

where $(h / m_p c)$ is a unit of distance, measured in terms of Compton-wavelength of pi-meson; and the constant $[G m_p^2 / h c]$ denotes the strength-ratio of gravitational and electric forces.

Or, in terms of energy:

$z_c = h \Delta \nu / h \nu$

$= [G m_p^2 / h c] [D / (h / m_p c)]$. …….....(7)

That is, the reduction in energy of photon due to cosmological red-shift is proportional to the strength-ratio of gravitational and electric forces.

(ii)

Alternatively, let us define reduction in electrostatic potential-energy of an electron-proton-system z_e as:

$z_e = [\ e^2 / r_e\ ] - [\ e^2 / (\ r_e + D)] / [\ e^2 / (\ r_e + D)]$

Where e is electric-charge, r_e is 'classical radius of electron' and D is 'luminosity distance'.

i.e.

$z_e = e^2\ [\ r_e + D - r_e\ ]\ [\ r_e + D] / [\ r_e\ (\ r_e + D)\ e^2\ ]$.

i.e. $z_e = D / r_e$. ……..(8)

From the 'Large-Number-Coincidence', we know, that:

$(G\ m_e\ m_p / e^2\ ) = (\ r_e / R_0\ ) = (\ m_p / M_0\ )^{1/2} = 10^{-40}$;

Where: M_0 is total-mass, and R_0 radius of the universe.

i.e. $z_e = 10^{40}\ (\ D / R_0\ )$. ……..(9)

Since R_0 is defined as a distance at which the recessional-velocity $H_0\ D = c$, so, the product:

$H_0\ \ R_0 = c$;

Therefore, $z_c = H_0\ D / c = D / R_0$ ……..…(10)

From the expressions (8), (9) and (10), we get:

$z_c = 10^{-40}\ z_e$. ……....(11)

That is: 'cosmological-red-shift, at a distance D is ($G\ m_e\ m_p\ / e^2$) times the reduction expected from the 'electrostatic potential energy of an electron at that distance D.

Thus we find that the loss of energy of the photons in the 'cosmological red-shift' is proportional to the 'strength-ratio' of gravitational and electric forces. Therefore any mechanism which can produce the loss proportional to this 'strength-ratio' is likely to be possibly correct explanation.

Some more alternative interpretations of the 'cosmological red-shift':

Robert K. Adiar, in his book: "Concepts in Physics" [6] has presented a derivation that:

$M_0 c^2 - G M_0 M_0 / R_0 = 0$ Where M_0 is total mass of the universe, and R_0 is 'radius of the observable universe.

i.e. The gravitational potential energy of the universe is equal to energy of total-mass of the universe.

i.e. $G M_0 M_0 / R_0 = M_0 c^2$ …… (1)

This expression helped this author to explain the recurrences of the large-number 10^{40} in astrophysics [3] as follows:

Since: $G M_0 M_0 / R_0 = M_0 c^2$

i.e. $G M_0 m_e / R_0 = m_e c^2 = e^2 / r_e$ ……(2)

i.e. $r_e / R_0 = e^2 / G M_0 m_e = (e^2 / G m_p m_e) (m_p / M_0)$

i.e. $(r_e / R_0) (G m_p m_e / e^2) = (m_p / M_0)$ …(3)

Further derivation can be read from the ref [3]. Here let us proceed from the expression-2

i.e. $G M_0 m_e / R_0 = m_e c^2$ ……..(4)

i.e. $G M_0 m_e / R_0^2 = m_e (c^2 / R_0)$…....(5)

Since we know that radius of the universe R_0 is defined as a distance at which the recessional-velocity of the galaxies ($H_0 D$) attains the speed of light (c):

i.e. $H_0 R_0 = c$

i.e. $R_0 = (c / H_0)$ ……(6)

Substituting (6) in (5):

$G M_0 m_e / R_0^2 = m_e (H_0 c)$…… ….....(7)

The expression-4 implies that mass and energy of an electron is because of its 'cosmic gravitational potential energy'. Similarly mass and energy of every piece of 'matter' is because of its 'cosmic gravitational potential energy'. And the expression-7 implies that every piece of matter and energy feels a 'cosmic gravitational force' equal to its mass times the acceleration ($H_0 c$).

Now, extending these expressions (4) and (7) for the 'photons', we get:

$G M_0 (h f / c^2) / R_0 = (h f)$ …...……..(8)

And

$G M_0 (h f / c^2) / R_0^2 = (h f / c^2) (H_0 c)$……(9)

When the photon moves a distance *D*, equal to the luminosity-distance of its source from us, the work done by the photon to overcome the 'cosmic gravitational force' is:

Work done = (Force) . (Distance) i.e.:

$[G M_0 (h f /c^2) / R_0^2] D = (h f / c^2) (H_0 c) D$…….(10)

This is what we find in the case of 'cosmological red-shift', as follows:

The linear part of the 'cosmological red-shift' is expressed as:

Cosmological red-shift (z_c) = ($h f_0 - h f$) / ($h f$)

= $H_0 D / c$

i.e. $(h f_0 - h f) = (h f / c^2) (H_0 c) D$ ……(11)

From the expressions (10) and (11) we find that the loss in energy of the cosmologically red-shifting photon ($h f_0 - h f$) is equal to the work done by the photon against the 'cosmic gravitational force' felt by it, i.e. ($h f / c^2$) ($H_0 c$) *D*.

After every unit distance the energy of the photon gets reduced. So the loss in energy of the photon goes on reducing with every subsequent unit distances. Thus 'cosmological red-shift' automatically becomes a non-linear function of distance, as observed in the case of distant galaxies.

As a supportive evidence for the above theory, let us look at the values of decelerations experienced by Pioneer-10, Pioneer-11, Galileo and Ulysses space-probes [7]:

(i) For Pioneer-10, $a = (8.09 \pm 0.2) \times 10^{-10}$ m / s^2

(ii) For Pioneer-11, $a = (8.56 \pm 0.15) \times 10^{-10}$ m / s^2

(iii) For Ulysses, $a = (12 \pm 3) \times 10^{-10}$ m / s^2

(iv) For Galileo, $a = (8.0 \pm 3) \times 10^{-10}$ m / s^2

All these decelerations are of the same order of magnitude as $H_0\, c$ = 6. 87 x 10^{-10} m/s^2; and match strikingly with the 'critical-acceleration' a_0 of MOND; an extremely rare-probability coincidence. Matching of four different decelerations, in spite of the differences in their mass, velocities and directions, is itself a striking coincidence; and its matching with the deceleration experienced by the 'cosmologically red-shifting photon' cannot be ignored by a scientific mind as a coincidence. Slight differences in their values can be attributed to mundane effects like thermal radiation. Moreover, the extra-galactic photon experiences some gravitational blue-shift when it enters the gravitational-field of our milky-way galaxy. If we can send Hubble-like telescope out-side our milky-way galaxy then the value of $H_0\, c$ may be found very close to the decelerations of the above space-probes.

This value of acceleration ($H_0\, c$) also seems to play some role in the formations of structures of: nucleus-of-atom, globular-clusters, spiral-galaxies, galactic-clusters and the whole universe; as Sivaram C. has found interesting coincidences [8-11] that:

(i) For a typical atomic nucleus of mass m_n , *(A = 150)*

$a = G\, m_n / r_n^2 \sim 1.0 \times 10^{-10}$ m / s^2

(ii) For a globular cluster of mass 10^6 solar-masses and radius R_g = 100 pc,

$a = G\, M_g / R_g^2 \sim 10^{-10}$ m / s^2

(iii) For a spiral galaxy of mass $M_{gal} = 10^{12}$ solar-masses and radius R_{gal} = 30 kpc,

$a = G\, M_{\rm gal} / R_{gal}^2 \sim 0.8 \times 10^{-10}$ m / s^2

(iv) For a typical cluster of galaxies, $M_c = 10^{16}$ solar-masses and radius R_c = 3 Mpc,

$a = G\, M_c / R_c^2 \sim 10^{-10}$ m / s^2

(v) Also, for the universe as a whole, with a density of 10^{-29} grams/ cm^3 and radius $R_0 = 10^{28}$ cm,

$a = c\, H_0 = 6.87 \times 10^{-10}$ m/s^2

(vi) And, the value of 'critical acceleration of MOND, $a_0 \sim 10^{-10}$ m / s^2

Additionally we can consider the following derivation: (Can be removed based on learned referee's advice)

Let us assume that the 'cosmological-red-shift' is partly a gravitational-effect. The photon emitted by a supernova, and reaching us on earth, experiences some gravitational-pull from the mass within the sphere of radius r equal to the 'luminosity-distance' D. The change in gravitational-potential-energy of a photon of mass $m = (h f / c^2)$ will be:

$$\Delta E = G\ (4/3)\ \pi\ \rho_c\ D^3\ m\ / D$$

Where:

ρ_c is average density of matter in the universe;

$\rho_c = 3 H_0^2 / (8 \pi G) = 9.6 \times 10^{-27}$ kg-m^{-3} ; [Ref.12]

i.e. $\Delta E = [G\ (4/3)\ \pi\ \{ 3 H_0^2 / (8 \pi G) \}\ D^3 (m)] / D$

i.e. $(\Delta E) = (1/2) (m)\ H_0^2\ D^2$ ……..….(12)

Now, assuming this gravitational-potential-energy as the kinetic energy of body of mass m, as assumed in the case of expanding model of the universe:

$(1/2)\, m\, v^2 = (1/2) (m)\ H_0^2\ D^2$ ..……..…..(13)

i.e. $v = H_0\ D$

We have been interpreting this velocity as the 'recessional-velocity' of the galaxies; whereas our derivation suggests that, the reduction in energy of the 'cosmologically red-shifting photon' can be because: the photon has to work against the gravitational-pull of the mass within the sphere of radius D.

The expressions-12 & 13 are correct as long as the 'luminosity-distance' D is smaller than $R_0/2$; that is, for the cosmological-red-shifts up to 0.5; but when $D > (R_0/2)$, a part of the sphere of radius D falls outside the sphere of the universe; so the mass contained in the sphere of radius D start reducing from the expression: $(4/3)\ \pi\ \rho_c\ D^3$. So we observe lesser red-shifts than expected from the distant supernovae.

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