The electromagnetic wave evolution on very long distance

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Abstract

We explain the radiation's redshift $\mathbb{Z}$ from far away Galaxies using only Maxwell's classical equations and the energy conservation principle. Hubble's law sprouts out naturally as the consequence of the transformation of this radiation on long distances. We compute the constant H_0 ($84,3\ Km \cdot s^{-1} \cdot Mpc^{-1}$) from the Pioneer satellite data and explain its anomalous behaviour. We resolve some situations that are still enigmatic for the actual cosmology. We review the distance modulus formula and evaluate the limits of cosmological observations.

Contents

1 Introduction

I nterpreting the redshift $\mathbb{Z}$ of the radiation coming from the distant galaxies as a Doppler effect implies that those galaxies are moving away from the observer. In 1929 Edwin Hubble [1] [2] showed that the receding speed v of the observed galaxies was proportional to their distance z from the observer, was isotropic and related by the proportionality constant H_0. In the following years, this constant has been evaluated to 73 kilometres per second per Mega parsec but recently revised according to Planck satellite's data [3] to 67 kilometres per second per Mega parsec. Hubble law is written as,

$$v = zH_0 \tag{1.1}$$

where v is the source receding speed, z its distance from the observer and H_0 the proportionality constant. The redshift $\mathbb{Z}$ is a measure of this speed relative to light's vacuum speed

$$\mathbb{Z} = \frac{v}{c} \tag{1.2}$$

so that the distance is given as

$$z = \frac{c\mathbb{Z}}{H_0} \tag{1.3}$$

Relative to the source wavelength λ_0 and the observed wavelength λ, the redshift is

$$\mathbb{Z} = \frac{\lambda - \lambda_0}{\lambda_0} \tag{1.4}$$

Such interpretation infers an expanding universe since all observable objects seems to speed away the farther they are from the observer. Conversely, this implies [4] that $13,7$ billions years ago ($\frac{1}{H_0}$), all the universe was embedded in a singularity that exploded to produce the expanding universe that we are observing today.

T he Doppler effect being the ratio of source's speed to light's speed and the fact that nothing can exceed the speed of light this ratio must always be lower than one. But it is common to observe galaxies showing $\mathbb{Z}$ ratios greater than one up to values of 12 according to the more recent observations [5] [6]. This goes against interpreting the redshift as Doppler caused and also against an expanding universe.

B ut since Hubble discovery [1] and coupled to Lemaître thesis [7] [8] [9] [10], nearly all cosmology theoreticians agree on a new kind of universe expansion. This is no more an explosion of matter into space but the more esoteric concept of a space expansion which is seen through the general relativity glasses. The expanding space idea explains the redshift by the stretching the light rays suffers during their travel through space. Considering the elasticity of space is mere speculation because there aren't any experiences possible to prove it. This is an open door to all kinds of exotic universe models and even to questioning the known observed properties of matter : Cameron [11], Terazawa [12].

O bserving light or photons in our local universe as well as in the laboratory shows us that photons are particles or waves that keep their properties indefinitely. On the contrary, atomic particles have a measurable lifetime and can decay into other particles. Since the light speed is the maximum speed of any interaction that may happen in the universe this implies that the photon cannot suffer any other action except to move. Then time doesn't exist for the photon and it is immutable.

N othing may suggest that physic's laws are different at large distance from us than in our local environment. If we agree on the fact that there aren't any difference between the local universe and the most remote one and also between, then it is advisable to consider that the photons might suffer a kind of transformation between the emission point and the observer. This way the redshift can be justified differently than by the stretching of space. The sole laboratory that can permit this verification is the universe itself since the billion of years required. We propose to explain the redshift and Hubble law through such a slow transformation of the photons en route. According with the afore mentioned immutability of the photon, it must be must conceded that the maximum speed of any interaction in the universe is a little bit higher than the photon speed. This limit might be very close to the light speed because of the extremely long time required for photon transformation and the fact that all experiments done up to now are very well explained using the speed of light as the maximum speed limit of interactions in the universe. Then the photon is subject to structural transformation like any other denizen of the universe. This proposal seems to us much more acceptable and less esoteric than the elasticity of the space

O n an other side, consider the electromagnetic radiation that comes from all parts of the sky. It has a wider spectrum much larger than the optical one. Particularly, radio astronomers A. Penzias et R. Wilson [13] in 1964 discovered a uniform and isotropic radiation at a microwave frequency of $160,2\ GHz$ or $1,873\ mm$ in wavelength corresponding to a temperature of $2,72548\ ^{\circ}K$ [14]. This radiation couldn't be associated with any object of the sky and it's presence has been explained as a residual of the Big Bang that happened 13,7 billions years ago. Very energetic photons emitted at that time might have lost their energy through space expansion and the stretching of their wavelength. Today we would observe them as a cosmic microwave background residual (CMB).

W e already have proposed the transformation of the photons en route but this process mustn't proceed indefinitely, it must end somewhere. If it didn't, it would end up with an infinite number of photons of zero energy, an unacceptable situation in nature. We then propose that this endpoint of transformation happens when the photon energy reaches the CMB level. This way all radiation coming from everywhere melts in a kind of uniform fog that makes the physical limit of the observable world.

2 Theory

A ccording to our hypothesis, we proceed from the principle of energy conservation and built following two methods. The first one makes use of Maxwell's electromagnetic field equations while the second one is based on a sequence of successive photon mutations. Both gives the same results. Thereafter we consider the evolution of the electromagnetic wave.

2.1 Extreme propagation I

T he vacuum properties of an electromagnetic wave at very far distances are unknown to us. We suppose they are the same as they are locally meaning that Maxwell's laws of electromagnetism are the same everywhere in the universe. Then for a plane wave moving in the direction $\vec{k}$, the electrical field $\vec{E}$ and the magnetic field $\vec{H}$ are dependent on distance " z " and time " t ".

$$\vec{E} = \vec{i}\, E_x(z,t) \tag{2.1}$$

$$E_x = E\ exp\,[j\omega(t - \frac{z}{c}) + \theta] \tag{2.2}$$

$$\vec{H} = \vec{j}\, H_y(z,t) \tag{2.3}$$

$$H_y = H\ exp\,[j\omega(t - \frac{z}{c}) + \theta] \tag{2.4}$$

The Poynting vector represents the energy flux carried by the wave

$$\vec{\mathbb{S}} = \vec{E}\ \times\ \vec{H} \tag{2.5}$$

which is for the plane wave

$$\vec{\mathbb{S}} = \frac{E^2}{\mu_0 c}\,\vec{k} \tag{2.6}$$

Between extremely distant points the Poynting vector cannot represent the energy conservation principle. A redshift is observed meaning a variation of the wavelength, an absent parameter of $\mathbb{S}$. Meanwhile the Poynting vector certainly represents the mean energy carried by the photons of the wave each being of energy

$$E = \hbar\,\omega \tag{2.7}$$

When considering extremely long distances it is appropriate to consider the variation of the photon density N and it's energy level so that the energy regime is preserved and the quantity

$$\xi = N\hbar\omega \tag{2.8}$$

is kept constant on long distances while N and ω vary according to the distance z. Bringing together those two quantities

$$\mathbb{S} = \xi \tag{2.9}$$

$$\frac{E^2}{\mu_0 c} = \hbar N(z)\omega(z) \tag{2.10}$$

$$E = (\mu_0 c\hbar N(z)\omega(z))^{\frac{1}{2}} \tag{2.11}$$

shows an electrical field E varying as a function of the photon density N and the circular frequency ω both being dependent on the distance z. Then the components of the electromagnetic wave are

$$E_x = (\mu_0 c\hbar N(z)\omega(z))^{\frac{1}{2}}\ exp[j\omega(z)(t-\frac{z}{c})+\theta] \tag{2.12}$$

$$H_y = (\frac{\hbar N(z)\omega(z)}{\mu_0 c})^{\frac{1}{2}}\ exp[j\omega(z)(t-\frac{z}{c})+\theta] \tag{2.13}$$

Simplifying the writing

$$E_x = F_z\ exp\ [j\omega_z(t-\frac{z}{c})+\theta] = F_z exp\ [\cdot] \tag{2.14}$$

$$H_y = G_z\ exp\ [j\omega_z(t-\frac{z}{c})+\theta] = G_z exp\ [\cdot] \tag{2.15}$$

and knowing that

$$\frac{\partial E_x}{\partial z} = -\mu_0 \frac{\partial H_y}{\partial t} \tag{2.16}$$

we get

$$\frac{\partial E_x}{\partial z} = \frac{\partial F_z}{\partial z}\ exp\ [\cdot] + jF_z\ exp\ [\cdot]\ \{\frac{\partial \omega_z}{\partial z}(t-\frac{z}{c}) - \frac{\omega_z}{c}\} \tag{2.17}$$

$$\frac{\partial H_y}{\partial t} = G_z\ exp\ [\cdot]\ \{j\omega_z\} \tag{2.18}$$

Since that at any point in space

$$\frac{E}{H} = \frac{F_z}{G_z} = \mu_0 c \tag{2.19}$$

$$\therefore \quad G_z = \frac{F_z}{\mu_0 c} \tag{2.20}$$

then

$$\frac{\partial F_z}{\partial z} + jF_z\ \frac{\partial \omega_z}{\partial z}\ (t-\frac{z}{c}) = 0 \tag{2.21}$$

Considering

$$|E| = |F| = (\mu_0 c\hbar N_z \omega_z)^{\frac{1}{2}} \tag{2.22}$$

one get

$$\left\{N_z\,\frac{\partial\omega_z}{\partial z}+\omega_z\,\frac{\partial N_z}{\partial z}\right\}+j\,\left\{2N_z\omega_z\,\frac{\partial\omega_z}{\partial z}\,(t-\frac{z}{c})\right\}=0 \tag{2.23}$$

The real part between braces may be obtained differently by considering the fact that the quantity ξ (2.8) doesn't vary with distance so it's derivative is null and we get

$$\frac{\partial\xi}{\partial z}=N_z\,\frac{\partial\omega_z}{\partial z}+\omega_z\,\frac{\partial N_z}{\partial z}=0 \tag{2.24}$$

The solution of this differential equation is

$$N_z=\alpha\,e^{\frac{z}{\eta}}+C_1 \tag{2.25}$$

$$\omega_z=\beta\,e^{-\frac{z}{\eta}}+C_2 \tag{2.26}$$

where

$$\frac{\partial N_z}{\partial z}=\frac{\alpha}{\eta}\,e^{\frac{z}{\eta}} \tag{2.27}$$

$$\frac{\partial\omega_z}{\partial z}=-\frac{\beta}{\eta}\,e^{-\frac{z}{\eta}} \tag{2.28}$$

giving

$$\alpha\,C_2\,e^{\frac{z}{\eta}}=\beta\,C_1\,e^{-\frac{z}{\eta}} \tag{2.29}$$

This last equation being true for any value of z implies $C_1=C_2=0$. The limiting conditions are at $z=0$: $N_z=N_0$, $\omega_z=\omega_0$ so that

$$\alpha=N_0 \tag{2.30}$$

$$\beta=\omega_0 \tag{2.31}$$

and finally

$$N_z=N_0\,e^{\frac{z}{\eta}} \tag{2.32}$$

$$\omega_z=\omega_0\,e^{-\frac{z}{\eta}} \tag{2.33}$$

where the wavelength is

$$\lambda_z=\lambda_0\,e^{\frac{z}{\eta}} \tag{2.34}$$

The redshift is

$$\mathbb{Z}_z=e^{\frac{z}{\eta}}-1 \tag{2.35}$$

and for very short distances $z\ll\eta$

$$\mathbb{Z}_z=\frac{z}{\eta} \tag{2.36}$$

Here we have Hubble's law which in order to be recognized under it's classical form we chose

$$\eta = \frac{c}{H_0} \tag{2.37}$$

and generally we have for the distance scaling of the redshift

$$\boxed{\mathbb{Z}_z = e^{\frac{zH_0}{c}} - 1} \tag{2.38}$$

Inversely the distance expressed as a function of the redshift become

$$\boxed{z = \frac{c}{H_0}\ ln(\mathbb{Z}+1)} \tag{2.39}$$

and for the wavelength

$$\boxed{\lambda_z = \lambda_0\ e^{\frac{zH_0}{c}}} \tag{2.40}$$

and the photon density

$$\boxed{N_z = N_0\ e^{\frac{zH_0}{c}} = N_0\ (\mathbb{Z}+1)} \tag{2.41}$$

This shows that the calculation of cosmic distances using the classical Hubble law leads to overestimate real distances and that a logarithmic scale is the due way. The source wavelength and intensity grows linearly according to the redshift or exponentially for the distance. Figure 1 shows the relationship between the intensity and the wavelength as a function of the redshift for a Gaussian mimicking a spectral line. Any spectrum keeps its structure while its wavelength (2.40) and intensity (2.41) grows as a function of distance. The apparent receding speed is exponential as per equations (2.39) and (1.2).

$$z = \frac{c}{H_0}\ ln(\frac{v}{c}+1) \tag{2.42}$$

$$v = c\left\{e^{\left\{\frac{zH_0}{c}\right\}} - 1\right\} \tag{2.43}$$

2.2 Extreme propagation II

S pectral properties of atoms are well known in the laboratory. But when we observe them from far distances they show a redshift of their wavelength. Individual photons are characterized by a wavelength λ_0 and energy E_0

$$E_0 = \frac{hc}{\lambda_0} \tag{2.44}$$

Let us consider a cohort of N_0 photons per unit volume showing an energy per unit of volume G_0

$$G_0 = N_0 E_0 \tag{2.45}$$

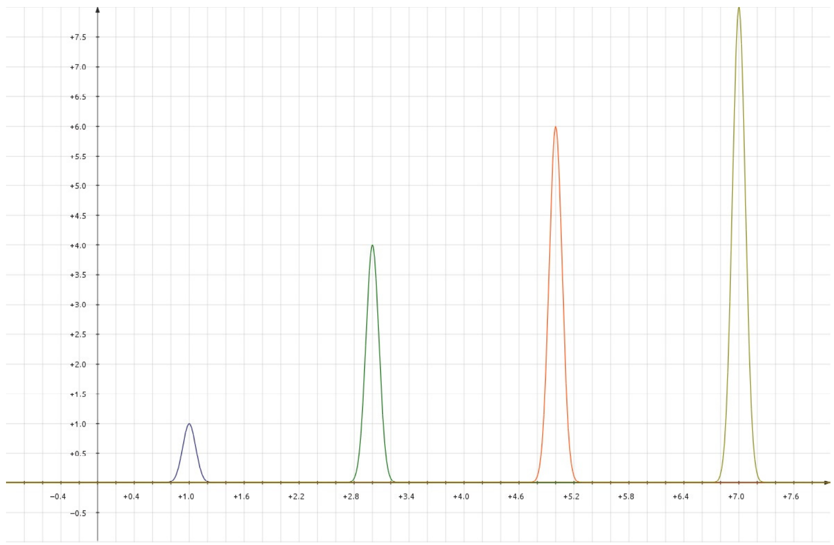

Figure 1: Spectral line evolution

After a time T there are $N_k > N_0$ photons per unit volume showing an energy per unit of volume G_k

$$G_k = N_k E_k \tag{2.46}$$

According to the principle of conservation of energy we write

$$N_k E_k = N_0 E_0 \tag{2.47}$$

Here we suppose that the transformation of the photons happens by successive leaps. A first one produces a new photon and the energy in the group is re-equilibrated. This process is the same for all other transformations happening in the group. After k transformations the energy of $N_0 + k$ photons becomes

$$E_k = \frac{N_0 E_0}{N_0 + k} \tag{2.48}$$

After k transformations the number of new photons is

$$k = N_0 \left\{ \frac{E_0}{E_k} - 1 \right\} \tag{2.49}$$

$$k = N_0 \left\{ \frac{\frac{hc}{\lambda_0}}{\frac{hc}{\lambda_k}} - 1 \right\} \tag{2.50}$$

$$k = N_0 \, \frac{\lambda_k - \lambda_0}{\lambda_0} \tag{2.51}$$

$$k = N_0 \, \mathbb{Z}_k \tag{2.52}$$

where we made use of the redshift $\mathbb{Z}_k$. The photon density is then

$$N_k = N_0 + k \tag{2.53}$$
$$N_k = N_0 + N_0\ \mathbb{Z}_k \tag{2.54}$$
$$N_k = N_0\ (\mathbb{Z}_k + 1) \tag{2.55}$$

The spectral line intensity I_k is proportional to the number of photons per unit of volume and it also increases the same way as

$$I_k = I_0\ (\mathbb{Z}_k + 1) \tag{2.56}$$

and the photon energy is

$$E_k = \frac{E_0}{\mathbb{Z}_k + 1} \tag{2.57}$$

and the wavelength is

$$\lambda_k = \lambda_0\ (\mathbb{Z}_k + 1) \tag{2.58}$$

B etween successive transformations the cohort moves a distance Δz. Without saying anything about the way such transformations happens, we suppose that the tension pushing the photons to transform is proportional to the actual photon density N_k. The number of new photons Δk per unit of distance is

$$\frac{\Delta k}{\Delta z} \propto N_k \tag{2.59}$$

and inversely, the distance of transformation is given by

$$\frac{\Delta z}{\Delta k} \propto \frac{1}{N_k} \tag{2.60}$$

which says that the distances where the transformations happens are inversely proportional to the photon density which constantly increases upon distance. If b is the proportionality constant and $N_k = N_0 + k$ we have for small intervals

$$\frac{\partial z}{\partial k} = \frac{b}{N_0 + k} \tag{2.61}$$

Upon integration

$$z = b\ ln(N_0 + k) + Cte \tag{2.62}$$

The initial conditions being $z = 0$ and $k = 0$ then

$$Cte = -b\ ln\ N_0 \tag{2.63}$$

and the distance is

$$z = b\ ln\ \frac{N_0 + k}{N_0} \tag{2.64}$$

Using equation (2.52) we write

$$z = b\ ln\ (\mathbb{Z}+1) \tag{2.65}$$

from which the redshift and the wavelength as a function of distance are

$$\mathbb{Z} = e^{\frac{z}{b}} - 1 \tag{2.66}$$

$$\lambda_z = \lambda_0\ e^{\frac{z}{b}} \tag{2.67}$$

Expanding the exponential as a series and keeping the first order terms for small distances

$$\mathbb{Z} = \frac{z}{b} \tag{2.68}$$

There we recognize Hubble's law and we set

$$b = \frac{c}{H_0} \tag{2.69}$$

From this point we compute the same equations as in the preceding section that is to say equations (2.38), (2.39), (2.40) and (2.41).

2.3 Wavelength evolution

T he wavelength transforms as an exponential of the distance (2.40). According to our model, the wavelength converge through the cosmic radiation background wavelength λ_{cmb} showing a redshift

$$\mathbb{Z}_{cmb} = \frac{\lambda_{cmb} - \lambda_0}{\lambda_0} \tag{2.70}$$

Up to this point we considered an energy decrease of the photons. We make the hypothesis that for photons less energetic than the CMB, there is an energy increase while their number density decreases. The wavelength of those photons decreases until it copes with the CMB one λ_{cmb} and a blue shift shall be observed for those. Consequently it shall be better to speak of a cosmic-shift that will be > 0 for red-shift or < 0 for blue-shift.

T he evolution of any wavelength according to distance is given by the following expression

$$\boxed{\lambda(z) = \lambda_{cmb} - (\lambda_{cmb} - \lambda_0)\ e^{-\frac{H_0 z}{c}}} \tag{2.71}$$

and the cosmic-shift is

$$\boxed{\mathbb{Z}(z) = \mathbb{Z}_{cmb}\ (1 - e^{-\frac{H_0 z}{c}})} \tag{2.72}$$

Figure 2 shows the wavelength evolution through the cmb.

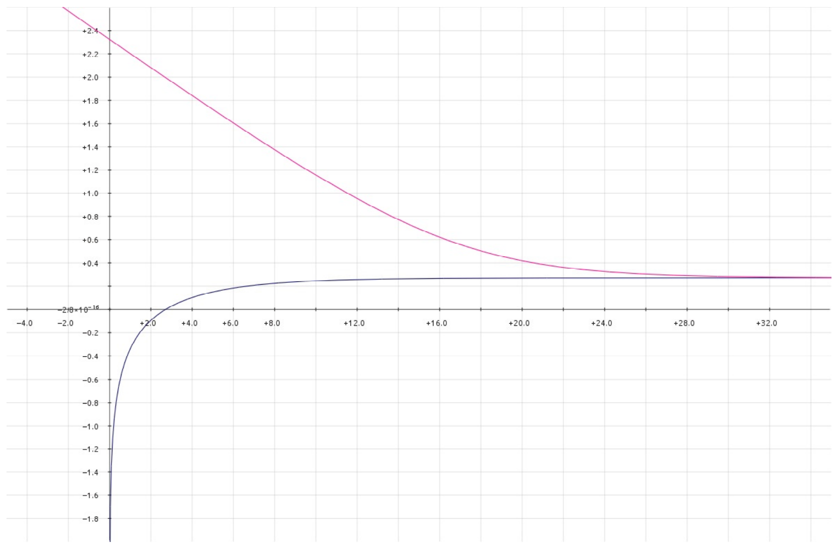

Figure 2: Wavelength evolution

3 The Hubble constant

T he enigmatic deceleration of the Pioneer satellite confirms our model of the spatial transformation of the electromagnetic wave. It gives us the opportunity to measure directly the value of the Hubble constant. The procedure might also be applied to galaxies and stars.

3.1 Pioneer

T he Pioneer 10 satellite has been decelerating constantly since it's departure from the solar system and still was when communications ended due to the loss of strength of the signal, Turyshev and Toth [15]. The Doppler signal measuring the satellite speed drifted constantly showing a deceleration of the satellite. Since the satellite was out of solar bounds it should have kept a constant speed and up to now no satisfactory explanation has been given to this phenomena.

T he satellite distance and speed were measured very precisely by observing a S band signal of frequency $\sim 2,1\ GHz$ sent from earth station and returned as $\sim 2,3\ GHz$ by the satellite in such a way that the stability and precision of the signal were independent of the satellite equipment. The satellite being out of solar bounds should have moved ballistically according to the classic mechanical laws. Throughout the whole journey, a constant frequency drift of $5,99 \pm 0,01 \times 10^{-9} Hz\ sec^{-1}$ has been observed toward a higher one. Interpreted as a Doppler shift, it is equivalent to a satellite deceleration of $8,74 \pm 1,33 \times 10^{-10}\ m\ s^{-2}$. We consider that this signal variation is nothing else than the effect of the transformation of the electromagnetic signal according to our model.

C learly if the satellite slows down, one will observe a blue shift of the Doppler signal which is already red shifted because of the satellite receding speed. Newtonian mechanic tell us that the satellite doesn't slow down but moves at constant speed. The signal round trip is increasing at a constant pace and according to our model, the signal must suffer a constant change. Since the mean frequency of the signal at $\sim 2,2\ GHz$ is lower than the cosmic microwave background of $160,2\ GHz$, the frequency of the signal must increase or equivalently the wavelength shorten. So the observed blue shift drift owing to the continuous increasing signal round trip distance. And the false impression of a slowing down of the satellite.

3.2 H_0

T his signal shift permits us to compute directly the Hubble constant. Let us take the time derivative of equation (2.71) and taking into account equation (2.40) and the following $z = ct$ and $\lambda = c/\nu$

$$\dot{\lambda} = H_0 \cdot (\lambda_{cmb} - \lambda_0) \cdot e^{-H_0 t} \tag{3.1}$$

$$\dot{\lambda} = H_0 \cdot \mathbb{Z}_{cmb} \cdot \lambda_0 \cdot e^{-H_0 t} \tag{3.2}$$

$$\dot{\lambda} = H_0 \cdot \mathbb{Z}_{cmb} \cdot \lambda \tag{3.3}$$

$$\boxed{H_0 = \frac{\dot{\lambda}}{\lambda} \cdot \frac{1}{\mathbb{Z}_{cmb}}} \tag{3.4}$$

$$\boxed{H_0 = -\frac{\dot{\nu}}{\nu} \cdot \frac{1}{\mathbb{Z}_{cmb}}} \tag{3.5}$$

Referring to the Pioneer satellite data, we select as the mean frequency the value of $2,22345\ GHz$ which is between $\sim 2,1\ GHz$, and $\sim 2,3\ GHz$. Using (2.70), the cosmic shift is

$$\mathbb{Z}_{cmb} = \frac{\nu_0 - \nu_{cmb}}{\nu_{cmb}} \tag{3.6}$$

$$\mathbb{Z}_{cmb} = \frac{2,22345 - 160,2}{160,2} = -\ 0,986121 \tag{3.7}$$

In this case the reception frequency is nearly the same as the emission one so the Hubble constant value is

$$H_0 = \frac{5,99 \times 10^{-9}}{2,22345 \times 10^9 \cdot 0,986121} = 2,731929 \times 10^{-18}\ sec^{-1} \tag{3.8}$$

Using $1\ Mpc = 3,0856 \times 10^{19} Km$

$$H_0 = 2,731929 \times 10^{-18} \cdot 3,0856 \times 10^{19} = 84,29852\ Km\ sec^{-1}\ Mpc^{-1} \tag{3.9}$$

$$\boxed{H_0 = 84,3\ Km\ sec^{-1}\ Mpc^{-1}} \tag{3.10}$$

3.3 Galaxies

I n the context of a slowing down expanding universe, Loeb [16] has proposed to measure the variation of the redshift of galaxies as a function of time. Since there isn't any such phenomenon but only a distance change due to the peculiar velocity of the galaxies in the direction of observation, there will be a measurable red-shift or blue-shift independently of the distance of those galaxies. Long term observations depending on the intrinsic speed of the galaxies will be needed.

I f we can follow the frequency drift of a signal from a moving satellite and then derive the value of the Hubble constant, we can consider it possible for galaxies. Then for any galaxy at any distance, monitoring over many years the the drifting of a spectral line such as Lyman α or H_α will enable us to compute Hubble constant using equation (3.4). Also it will be easy to check the constancy of the Hubble constant as a function of distance. Using equations (3.4), (2.70), (1.4), the intrinsic speed of the source v_{int} and the extra time taken by the source T and by light t

$$\dot{\lambda} = \lambda\, H_0\, \mathbb{Z}_{cmb} \tag{3.11}$$

$$\Delta\lambda = \Delta t\, \lambda\, H_0\, \mathbb{Z}_{cmb} \tag{3.12}$$

$$\Delta t = 2\, \frac{v_{int}\, \Delta T}{c} \tag{3.13}$$

$$\Delta\lambda = 2\, \Delta T\, \frac{v_{int}}{c}\, H_0\, \mathbb{Z}_{cmb}\, \lambda_0\, (\mathbb{Z}_{cos} + 1) \tag{3.14}$$

If during $\Delta T = 10\ years$, we observe the spectral line $\lambda_0 = H_\alpha = 6563$ from a galaxy situated at a redshift of $\mathbb{Z}_{cos} = 1$ for which it is estimated it has a receeding speed of $v_{int} = 1000\ km/s$ and using for the Hubble constant the value of $H_0 = 84,3\ km/sec/Mpc$, a drift of about $2,2 \cdot 10^{-4}$ shall be observed. The same procedure might be applied to stars having a better visibility.

4 Solved enigmas

M ore and more deviations or unexplained effects pop up in the context of an expansionist cosmology. Some of those phenomenons are very well explained by our model and here three are analysed.

4.1 Receding speed of the Cepheids

W e have shown that the apparent recession speed is exponential and not linear (2.43). If a linear relation is kept (1.1) when observing objects situated at farther and farther distances or increasing red-shifts, higher and higher values of the Hubble constant H_0 will be found. This explains the difference between Cepheids close to us and others farther from us. This fact is shown and discussed in the paper of Arp [17] where he looks for an explanation by an excess of redshift for the distant Cepheids. Figure 3 reproduces figure 4 of his paper where the increasing values of the Hubble constant as a function of distance are clearly seen.

4.2 Luminosity increase

I n a study of two ultra and hyper luminous galaxy groups (Lyman Break galaxies) showing high redshift, Oteo and al [18] find that all galaxies of a group at $\mathbb{Z} \sim 1$ have a magnitude less than $11,7$ and all those of an another group at $\mathbb{Z} \sim 3$ have a magnitude greater than $12,4$ while both groups were constructed to make two homogeneous populations with identical properties. Those investigators questions the possible influence of the redshift on the evolution of the far infrared radiation FIR coming from those galaxies. Considering our model, it is clear that the observed luminosity increases as a function of it's redshift (2.41). In this case, the redshift ratios between the two groups is simple to double $(3+1)/(1+1) = 2$. The luminosity will show the same ratio or in term of magnitude it will translate to a difference of $\sim 2,5\ log(2) = 0,753$. This is the observed magnitude difference between the two groups $[> 12,4]\ -\ [< 11,7] = [> 0,7]$.

4.3 Cosmic microwave background and supernova

Y ershov and al. [19] has showed a high correlation between the local increase of the cosmic microwave background temperature T_{sn} at supernova positions and the redshift of those supernova $\mathbb{Z}_{sn}$. Looking at SN type Ia they find that the temperature increases as $T_{sn} = 58,0 \pm 9,0\ \mathbb{Z}_{sn}\ [\mu K]$. This local temperature excess is proportional to the associated redshift of those supernova. The expansionist cosmology cannot explain this phenomenon. However this effect confirms our transformation model of the electromagnetic energy as a function of distance. At those supernova spots, there is always an excess of temperature over the cosmic background. And this increase is directly proportional to the source's distance or its red-shift.

S upernova are considered cosmic standard because they all have the same properties and produce identical energy spectra, Coelho [20]. Let us consider the energy spectra of such supernova where we define a small wavelength band $\lambda_1 - \lambda_2$ bracing the CMB

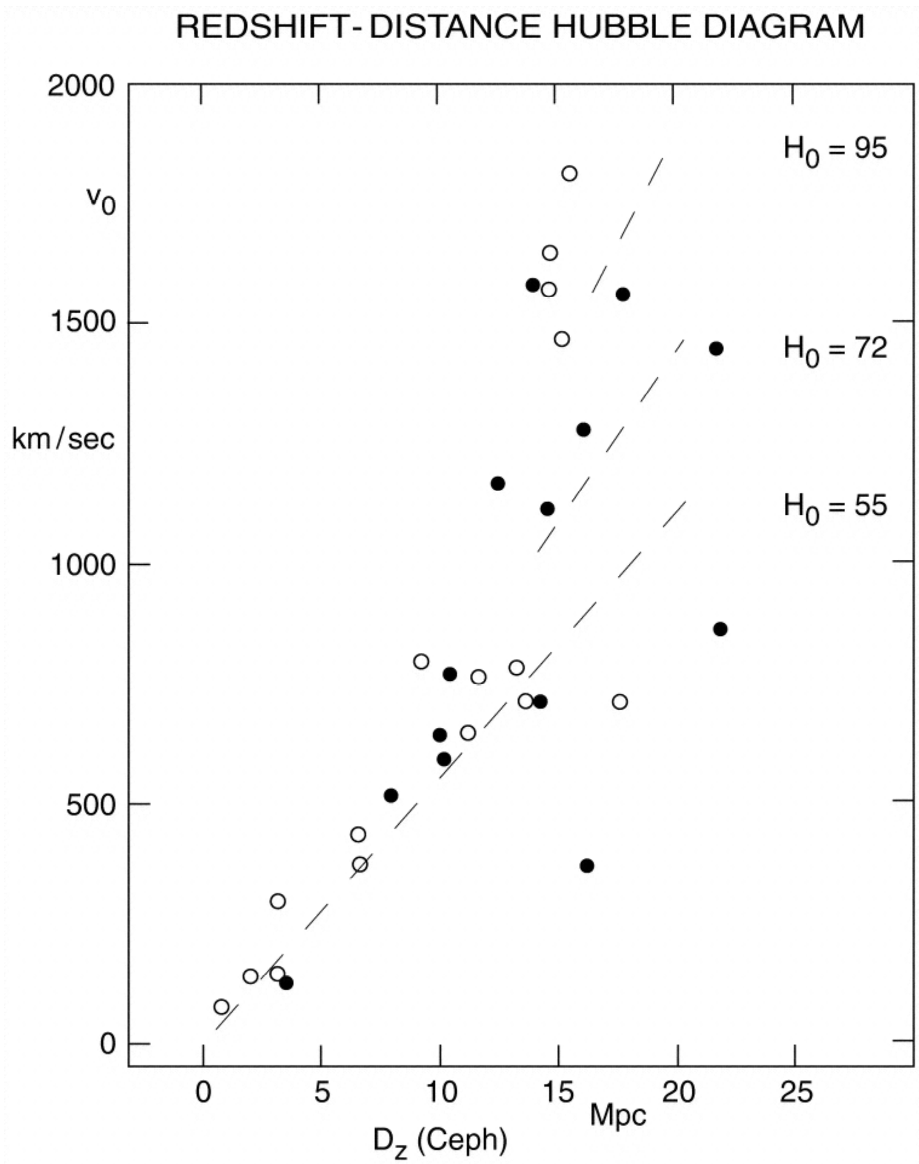

Figure 3: Hubble constants as a function of distance for Cepheids

wavelength λ_{cmb}. We suppose that the photons density $I(\lambda)$ into that interval is constant I_0 with the photon energy as $\frac{h\,c}{\lambda}$. The total energy in that band is

$$E = \int_{\lambda_1}^{\lambda_2} I_0\, \frac{hc}{\lambda}\, d\lambda \tag{4.1}$$

$$E = I_0 hc \big\{ \ln(\lambda_2) - \ln(\lambda_1) \big\} \tag{4.2}$$

At a distance d or a red-shift $\mathbb{Z}$, we observe this band slightly contracted around the CMB wavelength λ_{cmb} that is between λ_1' and λ_2'. Using (2.71) and (2.40) we get

$$\lambda_1' = \lambda_{cmb} - (\lambda_{cmb} - \lambda_1)\, e^{-\frac{H_0 d}{c}} \tag{4.3}$$

$$\lambda_1 = \lambda_{cmb} - (\lambda_{cmb} - \lambda_1')\, e^{\frac{H_0 d}{c}} \tag{4.4}$$

$$\lambda_1 = \lambda_{cmb} \left\{ (1 - \frac{\lambda_{cmb} - \lambda_1'}{\lambda_{cmb}} (\mathbb{Z}+1) \right\} \tag{4.5}$$

$$\ln(\lambda_1) = \ln(\lambda_{cmb}) + \ln\left\{ 1 - \frac{\lambda_{cmb} - \lambda_1'}{\lambda_{cmb}} (\mathbb{Z}+1) \right\} \tag{4.6}$$

$$\ln(\lambda_2) = \ln(\lambda_{cmb}) + \ln\left\{ 1 - \frac{\lambda_{cmb} - \lambda_2'}{\lambda_{cmb}} (\mathbb{Z}+1) \right\} \tag{4.7}$$

$$\ln(\lambda_2) - \ln(\lambda_1) = \ln\left\{ 1 - \frac{\lambda_{cmb} - \lambda_2'}{\lambda_{cmb}} (\mathbb{Z}+1) \right\} - \ln\left\{ 1 - \frac{\lambda_{cmb} - \lambda_1'}{\lambda_{cmb}} (\mathbb{Z}+1) \right\} \tag{4.8}$$

and making an approximation of the logarithm by its argument

$$\ln(\lambda_2) - \ln(\lambda_1) = \frac{(\mathbb{Z}+1)}{\lambda_{cmb}}\, (\lambda_2' - \lambda_1') \tag{4.9}$$

A substitution in (4.2) gives

$$E = \frac{I_0\, h\, c\, (\mathbb{Z}+1)}{\lambda_{cmb}}\, (\lambda_2' - \lambda_1') \tag{4.10}$$

The instrument measure a temperature increase ΔT converted through the Boltzman constant as an energy increase

$$\Delta E = k_B\, \Delta T \tag{4.11}$$

Then we get for the temperature increase

$$\Delta T = \frac{I_0\, h\, c\, (\lambda_2' - \lambda_1')}{k_B\, \lambda_{cmb}}\, (\mathbb{Z}+1) \tag{4.12}$$

Our model predicts a temperature increase proportional to the red-shift and is corroborated by the Yershov paper. This paper points out that the measure made at the frequency of 143 *Ghz* or $1,67$ *mm* shows the best correlation for a coefficient value of $67,6 \pm 6,3\ ^\circ\ \mu K$. If we suppose a band of $0,8$ *mm* and use that wavelength as a substitute for the CMB wavelength we get

$$\Delta T = \frac{1,05 \times 10^{-34}\ 3 \times 10^{8}\ 0,8 \times 10^{-3}}{1,38 \times 10^{-23}\ 1,67 \times 10^{-3}}\ I_0\ (\mathbb{Z}+1) \tag{4.13}$$

$$\Delta T = 1093\, I_0\, (\mathbb{Z}+1)\ ^\circ\mu K \tag{4.14}$$

5 Distance

F ollowing the electromagnetic wave distance transformation, we need to review the distance modulus. We evaluate the maximum dimension of the observable world.

5.1 Distance modulus

L et us consider the increasing photon density (2.41)

$$N_z = N_0\ e^{\frac{zH_0}{c}} \tag{5.1}$$

A monochromatic source of luminosity L_{0,λ_0} at a wavelength λ_0 will look at a distance z as a longer wavelength λ_z (2.40)

$$\lambda_z = \lambda_0\ e^{\frac{zH_0}{c}} \tag{5.2}$$

Such source will produce a flux S_{z,λ_z} that an observer will measure as proportional to the increase of the photon density and inversely proportional to the squared distance

$$S_{z,\lambda_z} = L_{0,\lambda_0}\ \frac{e^{\frac{zH_0}{c}}}{(4\pi z^2)} \tag{5.3}$$

At two different distances d et f the corresponding fluxes will be S_{d,λ_d} and S_{f,λ_f}

$$S_{d,\lambda_d} = L_{0,\lambda_0}\ \frac{e^{\frac{dH_0}{c}}}{(4\pi d^2)} \tag{5.4}$$

$$S_{f,\lambda_f} = L_{0,\lambda_0}\ \frac{e^{\frac{fH_0}{c}}}{(4\pi f^2)} \tag{5.5}$$

whose ratio is

$$\frac{S_{d,\lambda_d}}{S_{f,\lambda_f}} = \left(\frac{f}{d}\right)^2\ e^{\frac{H_0}{c}(d-f)} \tag{5.6}$$

For this source, the magnitude difference between those two points according to the definition of magnitude is

$$m_d - m_f = -2,5\ log\ \frac{S_{d,\lambda_d}}{S_{f,\lambda_f}} \tag{5.7}$$

$$m_d - m_f = -2,5\ log\ \left\{\left(\frac{f}{d}\right)^2\ e^{\frac{H_0}{c}(d-f)}\right\} \tag{5.8}$$

At the distance $f = 10\ pc$, m_f become the conventional reference value for the absolute magnitude M. This magnitude difference is the definition of the distance modulus μ and then we have for this source

$$\mu = m - M = 5\ log\ d_{pc} - 5 - 1,086\ \frac{H_0}{c}\left\{d_{pc} - 10_{pc}\right\} \tag{5.9}$$

Using equation (2.39)

$$\mu = 5\ log \left\{ \frac{c}{H_0} ln\ (\mathbb{Z}_d + 1) \right\} - 5 - 1{,}086\ \frac{H_0}{c} \left\{ \frac{c}{H_0} ln\ (\mathbb{Z}_d + 1) - 10_{pc} \right\} \tag{5.10}$$

Neglecting the very small value of 10 pc and using $H_0 = 84,3\ Kmsec^{-1}Mpc^{-1}$ and $\frac{c}{H_0} = 3,5563\ Gpc$ we obtain the expression for the distance modulus

$$\boxed{\mu = 42{,}755 + 5\ log\ ln\ (\mathbb{Z}_d + 1) - 1{,}086\ ln\ (\mathbb{Z}_d + 1)} \tag{5.11}$$

different from the classical one

$$\mu = 42{,}755 + 5\ log\ \mathbb{Z}_d \tag{5.12}$$

Table 1 shows the distance d and the distance modulus μ against the classical values as a function of the redshift $\mathbb{Z}$. The distance modulus grows up to a maximum at $\mathbb{Z} = 6,38$ and then decreases slowly. Included are the corresponding values of the expansionist model obtained fron Nick Gnedin calculator [20] using $H_0 = 67,3$ and $\Omega_0 = 0,315$. Figure 4 illustrates this table.

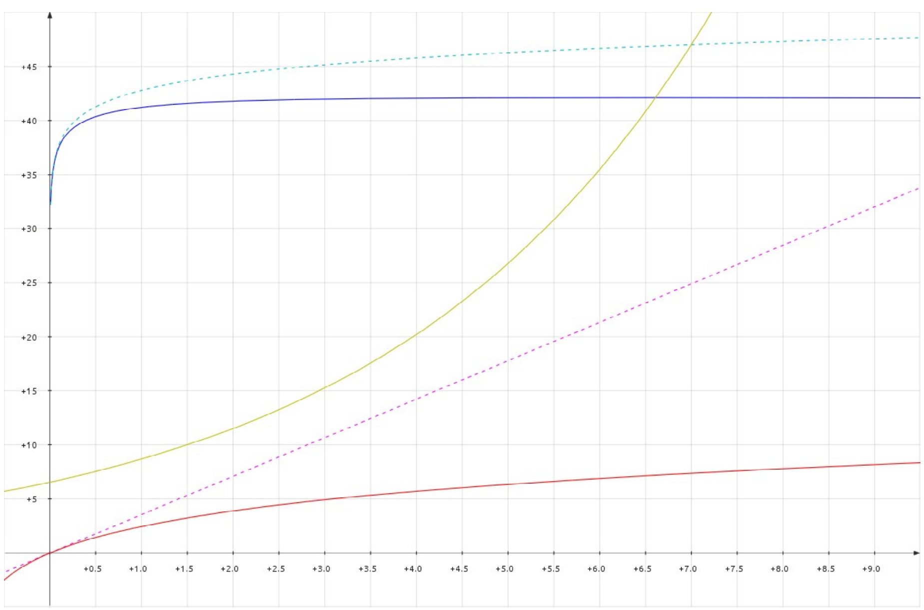

Figure 4: The distance modulus (upper curves), the distance (Gpc, lower curves) the wavelength ($H_\alpha \times 10^{-5}\ m$, exponential) and the classical values (dotted curves).

5.2 The world we can see

O ur model shows photon transformation along distance, ending when the photon energy correspond to the CMB radiation. At this point photons have a wavelength

Redshift $\mathbb{Z}_d$	Distance (2.39) d_{Gpc}	Distance modulus (5.11) μ	Classical distance (1.1) d_{Gpc}	Classical modulus (5.12) μ	Distance expansion model d_{Gpc}	Module Nick Gnedin calculator μ
0,1	0,34	37,54	0,36	37,75	0,48	38,42
0,2	0,65	38,86	0,71	39,26	1,02	39,85
0,3	0,93	39,56	1,07	40,14	1,61	41,04
0,4	1,20	40,02	1,42	40,76	2,25	41,77
0,5	1,44	40,35	1,78	41,25	2,94	42,34
1	2,47	41,20	3,56	42,75	6,81	44,17
2	3,91	41,76	7,11	44,26	15,97	46,02
3	4,93	41,96	10,67	45,14	26,07	47,08
4	5,72	42,04	14,23	45,76	36,72	47,82
5	6,37	42,07	17,78	46,25	47,75	48,39
6	6,92	42,08	21,34	46,64	59,06	48,86
6,38	7,11	42,09	22,69	46,78	63,42	49,01
7	7,40	42,08	24,89	46,98	70,60	49,24
8	7,81	42,08	28,45	47,27	82,31	49,58
9	8,19	42,06	32,01	47,52	94,16	49,87
10	8,53	42,05	35,56	47,75	106,14	50,13
20	10,83	41,86	71,13	49,26	230,36	51,81
30	12,21	41,70	106,69	50,14	359,09	52,78
40	13,21	41,57	142,25	50,76	490,15	53,45
50	13,98	41,46	177,82	51,25	622,76	53,97
100	16,41	41,06	355,63	52,75	1298,28	55,57
200	18,86	40,62	711,26	54,26	2676,14	57,14
300	20,30	40,34	1066,89	55,14	4069,21	58,05
400	21,32	40,13	1422,53	55,76	5470,00	58,69
500	22,11	39,97	1778,16	56,25	6876,02	59,19
1000	24,57	39,45	3556,31	57,75	13945,98	60,72
2000	27,03	38,90	7112,63	59,26	28171,69	62,25
3000	28,47	38,57	10668,94	60,14	42445,76	63,14

Table 1: Distance and distance modulus as a function of redshift according to our model, the classical model and the expansionist model.

of $1,873 \times 10^7$ $\mathring{A}$ corresponding to a temperature of $2,72548$ $^\circ K$. Considering the Hydrogen line $H_\alpha = \lambda_0 = 6563$ $\mathring{A}$, photons at end of course will have a redshift of

$$\mathbb{Z}_{cmb} = \frac{\lambda_{cmb} - \lambda_0}{\lambda_0} = \frac{1,873 \times 10^7 - 6563}{6563} = 2853 \tag{5.13}$$

The corresponding transformation distance $z = d$ according to the modified Hubble law (2.39) where $H_0 = 84,3$ $Km\ s^{-1}\ Mpc^{-1}$, $c = 3 \times 10^5$ $Km\ s^{-1}$, $1Mpc = 3,0856 \times 10^{19}$ Km and $1pc = 3,26$ al is

$$d_{cmb} = \frac{c}{H_0}\ ln\ \{\mathbb{Z}_{cmb} + 1\} \tag{5.14}$$

$$d_{cmb} = \frac{3 \times 10^5}{84,3}\ ln\ \{2853 + 1\}\ Mpc \tag{5.15}$$

$$d_{cmb} = 28,3\ Gpc = 92,3\ Gal \tag{5.16}$$

The CMB represents the true limit of knowledgeable universe, the maximum dimension of the observable universe not its physical dimension. This distance vary upon the wavelength of the photons. It is around $92,3$ Giga light years if we consider the H_α hydrogen line and $194,3$ Giga light years if we consider gamma rays. Table 2 shows some values very different from the usual classic value of $13,7$ Giga light-years which is nearly thirteen times smaller than the knowledgeable universe.

Line	λ_0 $[\mathring{A}]$	$\mathbb{Z}_{cmb}$	d_{cmb} $[Gpc]$	d_{cmb} $[Gal]$
L_α	1216	15402	$34,3$	$111,9$
L_∞	912	20536	$35,3$	$115,2$
H_α	6563	2853	$28,3$	$92,3$
H_∞	3646	5136	$30,4$	$99,1$
γ	1	$1,873 \times 10^7$	$59,6$	$194,3$

Table 2: Transformation distances

L et us look at Quasars which are of a very great luminosity and are usually very far away objects. A value of $Z = 3,638$ has been measured for Quasar Q0201+113 that put it at a relative distance of

$$\frac{d}{D} = \frac{ln(1 + 3,638)}{ln(1 + 2853)} = 0,1928 \tag{5.17}$$

It is about $1/5$ the theoretical observable limit or $5,46$ Gpc ($17,8$ Gly). ULAS J1120+0641 shows a $Z = 7,1$ and is relatively placed at 26% that is $7,4$ Gpc or $22,9$ Gal

6 Conclusion

T he expansionist model of cosmology also called the "Big Bang" is a speculative one. Instead of compounding with an elastic relativistic metric with adjustable parameters, we find more plausible our model based exclusively on Maxwell electromagnetism and the quantum world. Contrarily to tired light models it doesn't blur images but enhances their luminosity while reddening them.

O ur model shows that cosmological distances can be measured according to a logarithmic law of redshift. It gives a sound basis to the Hubble constant which we evaluate to $84,3\ Km\ sec^{-1}\ Mpc^{-1}$ directly from the Pioneer satellite data. And at the same time it solves the enigma it posed.

W e reviewed some problematic cases for the expansionist model and showed that they are naturally explained by our model.

W e reviewed the distance modulus according to our model and set new frontiers to the knowledgeable universe. The world is not physically limited to $13,7$ billion light-years but knowledgeable up to 100 billion light-years.

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