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The Constant of the Universe Expansion Acceleration Γ_H, the Einstein Variation of c and Parameters V_H, Ω, Λ and ɣ.

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Abstract

The Hubble-Lemaitre equation $\mathbf{v} = \mathrm{H} \cdot \mathbf{r}$ ($cm \cdot s^{-1}$) represented a linear function of the radial Space expansion velocity, if H would be a constant. Sometimes it has been assumed as H = 1/t, which sends back to the classical **v** = **r**/t. However, the later discovered acceleration required the additional condition for H to be, also, a function of time; or, opposed, the existence of a not yet defined dark energy. In a previous paper **[1]** it had been proposed a provisional expression for a constant Universe expansion acceleration as function of distance: $\mathbf{\Gamma} = \mathrm{H}^2$ ($cm \cdot s^{-2}$). Now, the substitution of **r** as a function of time, takes to five new equations of H, the Hubble velocity $\mathbf{v}_H$, the Hubble acceleration $\mathbf{\Gamma}_H$ and the positive Hubble potential V_H of the Space. So the proposed Hubble functions for the Space: H, $\mathbf{r}_H$, $\mathbf{v}_H$, $\mathbf{\Gamma}_H$ and V_H result higher than those in a gravitational field. All of these Hubble functions act in the total Space expansion though, into the Physical Universe, $\mathbf{\Gamma}_H$ is not perceived as it does, continuously, the opposed gravitational acceleration **g**. Otherwise, a revision is made of the Einstein equation for the **c** value as function of the gravitational potential φ. Additional proposals are made about the horizons definitions and parameters Ω, Λ and ɣ.

Keywords: Hubble-Lemaitre Equation, Critical Time, Proper Time.

1. Conventional Definitions

Hubble Flow: The outward displacement of external galaxies.

(H–L): The Hubble-Lemaitre equation.

Universe: the expanding Space that contains the Physical Universe.

Big Bang: an assumed singularity as the most probable origin of the Space, time, matter and physical laws.

2. The Hubble Functions: H, Velocity, Acceleration and Radius

From de (H–L) equation:

$$\mathbf{v} = \mathrm{H}\ .\mathbf{r} \tag{1}$$

it is possible to obtain the Hubble parameter H if **r** is expressed as a function of time and a function of the intensity of the expansive field **Γ**, at a given radius, in equation (1):

$$\mathbf{v} = \mathrm{H} \cdot \mathbf{r} = \mathrm{H} \cdot \mathbf{\Gamma} \cdot \mathrm{t}^2/2 = \mathbf{\Gamma} \cdot \mathrm{t}\ \left(\frac{\mathrm{cm}}{\mathrm{s}}\right)\ ;\ \text{so: } \mathrm{H} = 2/\mathrm{t} \tag{2}$$

Then, substitution of (2) in (1) gives:

$$\mathbf{v_H} = \frac{\mathbf{2r}}{\mathbf{t}} \tag{3}$$

so, the Hubble velocity in the accelerated expansion of the space could be expressed ed as

$$\mathbf{v_H} = \mathbf{2v} \tag{4}$$

since the Space expansion velocity does not depend on gravitation. Therefore, the (H-L) equation (1) could be written as

$$\mathbf{v}_H = H\mathbf{r} = \frac{2r}{t} = 2\mathbf{v} \quad (4a)$$

In that concerning the (H-L) acceleration $\mathbf{\Gamma}_H$, it may be obtained by substitution of equation (4) from a assumed Hubble acceleration equation:

$$\mathbf{\Gamma_H = v_H/t} \quad (5);$$

substitution of equation (3) in (5) lets obtain the (H-L) acceleration of the Space expansion:

$$\mathbf{\Gamma_H} = \mathbf{2r}/\mathbf{t^2} \quad (6)$$

$$\mathbf{\Gamma_H = H^2 r/2} \quad (7)$$

Even the Hubble radius of Space may be assumed from equation (4):

$$\mathbf{v}_H = 2\mathbf{v}; \quad \text{so, for a given time t,} \quad \mathbf{r}_H = 2\mathbf{r} \quad (8)$$

For example, in the accelerated Hubble field, if the present time is $t_o \sim 4.5x10^{17}$ (s), the present (H-L) parameter would be $H_o \sim 4.4x10^{-18}$ (s^{-1}); if the Universe scale factor had been assumed to be about $\mathbf{r}_o = 2x10^{28}$ (cm), its constant (Lartigue, 2016) acceleration must be, from equation (6), $\mathbf{\Gamma}_H \sim 2x10^{-7}$ ($cm \cdot s^{-2}$); it generates the Hubble expansion velocity of Space by the equation

$$\mathbf{v}_H = \mathbf{\Gamma}_H \cdot t_o \quad (9)$$

that gives $\mathbf{v}_H = 3\mathbf{c}$; so, $\mathbf{r}_H = 4x10^{28}$ (cm). The space expansion velocity reached the **c** value at a time $t_c = t_o/3$, when the Physical Universe had not completed its formation. Therefore, the present concepts of horizons should be re-defined: the particles horizon, usually assumed as the radius of the observable Universe, would mainly depend on the range and precision of the instrumentation. The events horizon has been defined as the distance where the fare objects could be detected in the future; however, it is assumed that, in an accelerated Universe, the light emitted from the Physical Universe limit will never reach the Earth, because the expansion velocity must be higher than **c**, a situation anyway occurred in the Physical Universe since the time t_c = 1/3 of the present time t_o. Therefore, the events horizon definition needs to be revised. Firstly, the electromagnetic radiation does not come from the Big Bang (except the CMB) but from astronomical objects, i. e. it is not generated in the external Space (a vacuum). Therefore, it is always emitted and eventually detected into the Physical Universe. Besides, it is evident that the physical fields do not alter the **c** velocity, i.e. it is a Physical Universe constant. So, in spite of the expansion velocity of such Universe, it always exists the possibility to detect the light from a fare object. To date, the farer astronomical object has been detected with a factor z ~12 (Keck MOSFIRE Spectroscopy, 2013), i. e. about $1.4x10^{19}$(cm). It means that the Observable Universe only covers the last $4x10^5$ years of the expansion.

The today best definitions of horizons are those given by reference (Sartory, 1996)**:**

If

$$\int_{to} dt/R(t) \quad (10a)$$

is finite or ∞, it is an event horizon.

If

$$\int^{to} dt/R(t) \quad (10b)$$

is finite, it is a particle horizon.

So, the present particle horizon could correspond to the last mentioned figure of $4x10^5$ (y). The respective not mentioned limits could be ($t > t_o$) or ∞ in the first case; and the Big Bang time (t_B) in the second case. Then, equation (10a) covers future events and equation (10b) the past ones. Therefore, both horizons presents an always growing value to be determined.

* In reference **[1]** it was proposed the constancy of $\mathbf{\Gamma}_H$.

3. The The Hubble Potential V_H and Parameters Ω, Λ, c and ɣ

The space expansion acceleration $\mathbf{\Gamma}_H$ (including the contained Physical Universe) would necessarily be the intensity of a (H-L) field V_H , that must be positive since it is opposed to the gravitational field of the Physical Universe:

$$V_H = \int_r \mathbf{\Gamma}_H \cdot d\mathbf{r} \tag{11}$$

So, from (6)

$$V_H = H^2\mathbf{r}^2/4 \text{ (cm/s)}^2 . \tag{12}$$

The Ω_t function has been defined as the ratio of the Universe density at a time t and the critical density of the Physical Universe (Lidsey, 2014) as:

$$\Omega_t = \rho_t/\rho_{cr} \tag{13}$$

This equation could be applied to the present time as:

$$\Omega_o = \rho_o/\rho_{cr} \tag{14}$$

If $\rho_o > \rho_{cr}$, $\Omega_o > 1$ and $k > 0$, that implies a future collapse of the Universe. If $\rho_o < \rho_{cr}$, $\Omega_o < 1$ and $k < 0$, it produces a forever expansion. If $\rho_t = \rho_{cr}$, $\Omega = 1$ and $k = 0$, that means a plane geometry.

The equation to determine ρ_{cr} has been deduced from a Friedmann equation where the parameter k is assumed 0, in order to get a plane geometry:

$$\rho_{cr} = 3H^2/8\pi G \tag{15}$$

Since H is a function of time (equation 2), the critical density could exist at a critical time as:

$$\rho_{cr} = 3/2\pi G(t_{cr}^2) \tag{16}$$

Then, the only way to obtain an actual t_{cr} value it should be to assume that $\Omega_o = 1$; so, it would be necessary to substitute ρ_{cr} by ρ_o in equation (16). The ρ_o value has been estimated in 1x 10^{-27} (g·cm^{-3}) if the Physical Universe would have a total mass of 3x10^{58}(g) and a radius of 2x10^{28} (cm); so, the critical time must be $t_{cr} \sim t_o/5$. Condensing the above constants it gives another expression of equation (16):

$$\rho_{cr} = 7.1\text{x}10^6/(t_{cr})^2 \text{ (g/cm}^3). \tag{16a}$$

From the assigned values $\Omega_o = 1$ and the known value of ρ_o , substitution of ρ_{cr} by ρ_o in equation (16a), it gives a critical time $t_{cr} = 8.4\text{x}10^{16}$(s); so $t_{cr} \sim t_o/5$. Therefore, while the critical times would remain lower than the successive present times, the accelerated expansion will maintain a plain geometry.

Otherwise, since most of the Space is empty, the density concept of the Physical Universe has not a significant meaning for the total Space, which will probably continue its Hubble accelerated expansion forever, even if it happens any Physical Universe collapse.

The **c** variation. Contrary to his postulate of Special Relativity, Einstein proposed an equation to determine the variation of the present $\mathbf{c}_o$ value as a function of the gravitational potential φ (Einstein, 1923)**:**

$$\mathbf{c}_\varphi = \mathbf{c}_o (1 + \varphi/\mathbf{c}_\varphi^2) \tag{17}$$

$$\varphi = - GM/\mathbf{r}_c \tag{18}$$

They may occur 3 possible states, accordingly to the φ value:

a) If $\varphi = 0$ (when $\mathbf{r}_c \rightarrow \infty$), $\mathbf{c}_{\varphi} = \mathbf{c}_o$.
b) Since $\varphi < 0$ (in a gravitational field) $\mathbf{c}_\varphi < \mathbf{c}_o$.
c) If $\varphi/\mathbf{c}_\varphi^2 = -1$, $\mathbf{c}_\varphi = 0$.

Even worse, a problem may appear if the value of the light velocity would depend, rather, on the moduli difference of gravitational and Hubble fields intensity, as:

$$\mathbf{c} = (\mathbf{g} - \mathbf{\Gamma}_H) \cdot t \tag{19}$$

So, at a time t ~ 10^{18}(s) and a Universe radius $\mathbf{r} \sim 10^{29}$(cm), both intensities will mutually cancel, so generating a light velocity $\mathbf{c} = 0$. Then it seems preferable to assume, independently, the expansion velocity of the Space as $\mathbf{v}_H = \mathbf{\Gamma}_H \cdot t$ and the Physical Universe to be pulled as a whole into the Space at the same velocity, while the light speed **c** remains constant into the Physical Universe. Otherwise, the Observable Universe radius has a z ~ 12 (Keck MOSFIRE Spectroscopy, 2013). i. e. $\mathbf{r}_{ob} \sim 1.4\text{x}10^{19}$ (cm) or 10^{-9} times lower than the foreseeable Universe radius; so, its gravitational potential has not varied enough, in the last century, to detect an internal variation of **c**, if equation (17) would be valid.

However, the deviation of light rays in the nearness of astronomical bodies shows the mass property of photons; the corresponding equation (Tagliaferro, 2015) for gravitational lens shows the angle deviation as functions of the potential and the impact parameter, without any change in the light velocity; furthermore, if the impact parameter is 0, it appears the Einstein ring. Otherwise, as an electromagnetic wave, it happens a deviation in the plane of the photons direction in the Faraday's experiment, without any change in their velocity. That is the reality in the Physical Universe: **c** = constant in a vacuum, though it could be different in the external Space.

The ɣ factor was discussed in reference (Hawkins, 1988) as a Special Relativity concept:

$$ɣ = 1/(1 - \mathbf{v}^2/\boldsymbol{c}^2)^{0.5} \quad (20)$$

where **v** is the velocity of a mass, measured at the reference frame time t_s ; this time, multiplied by the ɣ value, gives the proper time τ by the equation:

$$\tau = ɣt_s \ \text{(s)} \quad (21)$$

Otherwise, if **v** = **c**, the proper time becomes ∞, which could be assumed as a frozen time. If **v** > **c**, it would give an imaginary proper time, mentioned by reference (Lartigue, 2018) as a coordinate in the Euclidic space. To avoid an imaginary time, it would be necessary to modify the equation (20) for the external Space as:

$$ɣ_s = \left(1 - \frac{(\mathbf{nc})^2}{(\boldsymbol{\Gamma}_\mathbf{H}\cdot\mathbf{t})^2}\right)^{-.5} \quad (22)$$

where **v** = n**c** and (n ≥ 1) would be the increasing factor of **c**, at a time t > t_o . The fraction should always be smaller than 1 since matter velocity (n**c)** at time t_s cannot be higher than the space expansion velocity ($\boldsymbol{\Gamma}_H \cdot t_s$), at least till n > 600. So, the proper time in the external space (outside the gravitational field) would anyway remain as a real and positive number. This today impossibility in the Physical Universe, could be feasible for a future matter eventually traveling in the external space.

The Λ concept has varied from the Einstein's one (a constant necessary for a static Physical Universe), to be excluded by Friedmann in his dynamical equations; though, after the Hubble discovery of the Universe expansion, Λ has been proposed again to represent a mysterious dark energy or quintessence, which nature and mathematical expressions, as functions of time or distance, have not yet been specified (Peebles, 2014). Instead, the **Γ** acceleration constant was proposed (Lartigue, 2016) as function of the Hubble parameter H and distance **r**; and, in this article, $\boldsymbol{\Gamma}_H$ as function of **r** and t in equations (6) and (7).

4. Conclusions

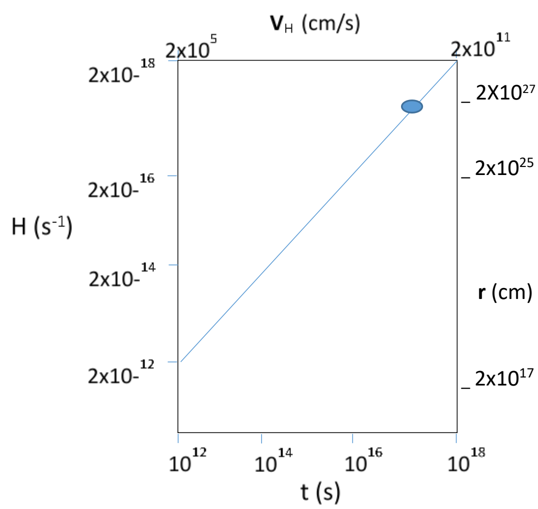

Figure 1. The scale factor r (cm) of Space and expansion velocity v_H (cm/s) as functions of H and time. The blue point corresponds to the present time t_o. The quotient of both abcissas gives the acceleration constant $\Gamma_H = 2x10^{-7}$(cm/s^2). The product of both abcissas gives the scale factor r of the Space

4.1-The relationship between the Hubble parameter and time has been given by equation (2) as H = 2/t (s^{-1}). The distances, in the Hubble field, results to be r_H = 2r. The Hubble velocity is v_H = 2v. The space expanding acceleration has been expressed as a constant by equation (7): $\Gamma_H = H^2r/2$ (cm/s^2). The positive Hubble potential of the Space expansion was deduced in equation (10) as: $V_H = H^2r^2/4$ (cm/s)^2. The present value of the Space expansion velocity is 3c. The previous horizons concepts have been questioned for an expanding Universe.

4.2 Regarding the Ω parameter, it has been proposed an equation (16) for the critical density as a function of the critical time; it was shown that the critical time has occurred at 1/5 of the present time, which guarantees a future expansion in a plane geometry.

4.3 It was proposed an equation (22) for the ɣ parameter in the spatial case (where it could be $v > c$) in order to obtain, always, a positive proper time τ.

4.4 Equation (2) has several implications: H diminishes as time increases; Hubble radius ($r_H = c \cdot t$) would become, if $v_H > c$, ($r_H = v_H \cdot t$). Otherwise, the light cone will continuously expand to become a circular surface that would cancel the "elsewhere" zones in the Loedel diagram.

4.5 Figure 1 shows the values of R, H, v_H and Γ_H as time functions.

Conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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