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CALCULATIONS OF SOME PHYSICAL ENTITIES OF THE UNIVERSE EXPANSION USING ITS SYMPLIFIED MATHEMATICAL MODEL

MALVINA BAICA AND MIRCEA CARDU

Abstract. In this paper we consider and solve the following problems related to the Universe Expansion (UE): 1.1. The determination of the mathematical relations for the velocity of the UE as a function of time. 1.2. The calculation of "the Hubble constant" value as a function of time.

1. Introduction

In [1] we presented a simple Mathematical Model for the UE. This model is valid for the time period between $\tau = 0.1$ and $\tau = 1.0$, where τ (the non-dimensional relative time) represents the relation between t, the time elapsed from the Bing-Bang (B-B) up to a given moment and the total time (t_{max}) elapsed from the moment B-B up to the present, thus $\tau = t/t_{max}$. Today it is accepted that the $t_{max} = 13.7$ billion years (billions means trillions here), respectively 4.32×10^{17} s. Again, referring to [1], we remember that the second fundamental non-dimensional entity which intervenes in the UE modeling is δ. The entity δ represents the relation between the spatial dimension (1) of the Universe at the moment τ and its dimension l_{max} at the present time, that is $\delta = 1/l_{max}$. It is known that $l_{max} = 93$ billions l-y (light-years), respectively 8.8×10^{23} km. Time period comprised between $\tau = 0.1$ and $\tau = 1.0$, for which our mathematical model presented in [1] is valid, as we showed above (see Fig.1, curve "c"), is satisfactory if we refer to the UE in its material form (stars, planets, galaxies, see [2]). We consider that for this material condition of the Universe it is very important to know the evolution of these physical entity over this expansion development process. In fact, we will refer to the expansion velocity as a principal physical entity and to the "Hubble Constant" calculated based on this velocity. Regarding to the values of the expansion velocity for the portion "b" of the curve b-c (Fig.1) corresponding to τ in the domain $\tau = (0...0.1)$, we need to mention that they are much bigger that it is hard to imagine. Thus, for example, for $\tau = 0.01$ the value of the expansion velocity v_b is $v_{0.01} = 3.46 \times 10^7$ km/s, that is 110 times larger than the velocity of light. In this case the velocity v_b was calculated based on the "geometry" of "curve "b" around the value $\tau = 0.01$, considering relation (3) of the next section.

2. Universe Expansion Speed

In Fig. 1, the points "a" are situated on the curve which represents the evolution of the entity δ in function of τ in the process of UE, entity resulted from astronomic measurements and valid arguments in the domain of the Cosmology. This curve was not traced with a continuous line in order not to alter the quality of the figure. The curve "c" represents the function $\delta = f(\tau)$ for the domain $\tau = (0.1...0.1)$ in conformity with the mathematical model presented in [1]. This is illustrated by the equation:

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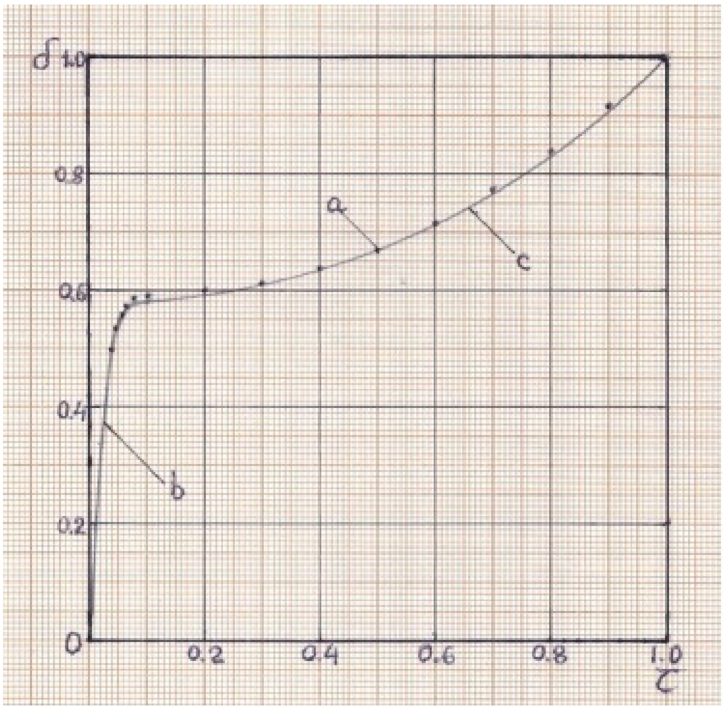

FIGURE 1.

$$\delta = 1.96 - (1.9044 - \tau^2)^{1/2}. \quad (1)$$

In order to calculate the value of the UE velocity (v), covering the development (evolution) of this process we start from the derivative of non-dimensional entity δ with respect to τ. We denote this derivative with:

$$B = d\delta/d\tau. \quad (2)$$

The value of the velocity (v) expressed in some specific units, let say in km/s, results from the relation (2), where $\delta = l/l_{max}$ and respectively $\tau = t/t_{max}$,as it shown in section 1. Thus, we have:

$$v = dl/dt = (l_{max}/t_{max})\beta[km/s]. \quad (3)$$

In relation (3) it is evident that l_{max} is expressed in [km] and t_{max} is expressed in [s]. With these values for l_{max} and t_{max} respectively, mentioned in section 1, we have:

$$v = 2.037 \times 10^6 d\delta/d\tau. \quad (4)$$

If we derivate function $\delta = f(\tau)$ of relation (1) and we introduce it in relation (4), for the portion "c" of the curve b-c we obtain:

$$v_c = 2.037 \times 10^6 \tau/(1.9044 - \tau^2)^{1/2}[km/s]. \quad (5)$$

In Fig. 2 is represented the curve of velocity variation v (having dimension [km/s]) in function of τ related to ordinate axis Ov placed at the left side of this figure. Also in Fig.

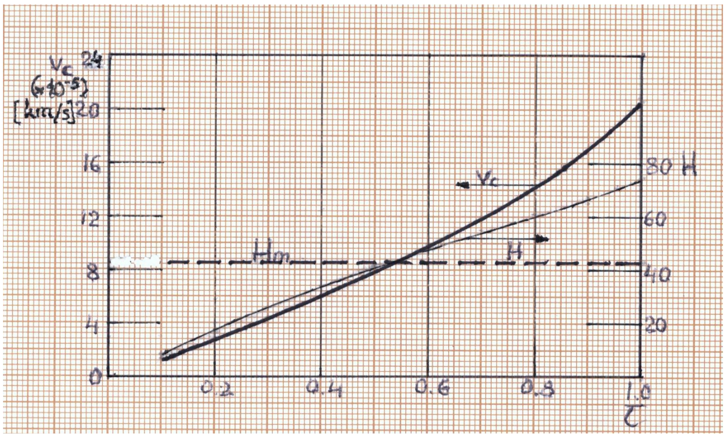

FIGURE 2.

2, but with the reference to the ordinate axis on the right, is represented the “Hubble Constant”. Our point of view regarding this problem will be discussed in the next section.

3. The Values of the “Hubble Constant” covering the Universe Expansion

Right from the beginning, when the phenomena of the continuous UE was discovered [2], there were questions that there must be some laws to rule this phenomena. The problem was solved by the reputable American astronomer Edwin Hubble [3] on the first part of the last century. His studies were based on the data obtained from his measurements effectuated at the Astronomic Observatory Mount Wilson in U.S.A. From in time shifting towards red of the light spectrum coming from the Galaxies (phenomena explained by Doppler Effect), Hubble concluded that the velocity with which one depart from one another is proportional with the distance between them. Consequently the Hubble Law was formulated and it has the following mathematical expression:

$$v = HL. \tag{6}$$

where v [km/s] is the velocity with which the measure l representing the Universe dimension increases, L[MPc] is the measure l at a desired moment, expressed in Megaparsec [MPc] and H is “ the Hubble Constant”. In its turn

$$L = \delta L_{max}. \tag{7}$$

It is known [2] that $L_{max} = 2.55 \times 10^4$ [MPc] and therefore

$$L = 2.85 \times 10^4 \delta [MPc]. \tag{8}$$

Using the relation (1) we obtain $L = f(\tau)$. We mention that Megaparsec is an astronomic unit for lengths and is equal with 3.084×10^{19} km, respectively with 3.26×10^6 l-y. At the beginning, the scientists who studied the problem of the UE indicated for H the value H = 500 km/s/MPc. Even Hubble in the beginning indicated for H the value of H = 460 km/s/MPc. Along the time the value of H was modified even to 50 km/s/MPc (Allan Sandage, Carnegie Institute in Washington), and to 100 km/s/MPc (Gerard De Vaucouleurs, Texas University) [4], [5]. In any case, the value of “Hubble Constant” is not “constant” with respect of τ, as we can see in Fig. 2 which represents this entity; we observe that H varies between $H_{0.1} = 10 km/s/MPc$ ($\tau = 0, 1$) and $H_{1.0} = 74 km/s/MPc$

($\tau = 1,0$). We mention that the "present" admissible value, that is 13.7 billion years after B-B, is about 70 km/s/MPc [3]. On the other side, the average value of H, resulted from our calculations, is $H_m = 42km/s/MPc$, as it is represented by the horizontal interrupted line in Fig. 2. What we have shown above constitutes the reason for what we consider inadequately the term Hubble "constant" and the word constant is written as "constant". There is a proposal to replace Hubble "constant" with Hubble "parameter", but we consider that it is more appropriate the word "coefficient" and thus "Hubble Coefficient". Coming back to the values for H mentioned above as being of 500 km/s/MPc and 460 km/s/MPc respectively, at a first glance they appear to be erroneous in rapport with the values presently discussed and in the way as the UE is performed in the "present" time (13.7 billion years after the B-B), at about 70 km/s/MPc. Examining carefully and with the assumption mentioned bellow, we arrive to the conclusion that those values apparently very large are correct. Namely, it is to suppose that these values were evaluated (or calculated) for that period in which from the plasma that constituted the entire Universe were coagulated the first of its material formation (stars, galaxies) [2].This mentioned phenomena had place about one billion years after B-B. Interpreting in the non-dimensional entity τ we get that $\tau = 1/13.7 = 0.073$. Appling the previous relations for δ, v and L, when $\tau = 0.073$ we get H = 530 km/s/MPc and for $\tau = 0.074$ we get H = 462 km/s/MPc. At the end of this chapter we like to stress the fact that the "Hubble Coefficient" had an important role in establishing some basic characteristics in the UE process, including also its evolution in time of these "dimensions".

4. Conclusions

Based on the simplified mathematical model of the Universe Expansion (UE) for the period of the non-dimensional time $\tau = (0,1...1,0)$, presented in [1], we found the mathematical relation for the variation of the velocity with which this corresponding process develops. From the values of this velocity introduced in the formula established by Hubble, we found the values of "Hubble Constant" in function of the non-dimensional time τ. Establishing that this so called "Hubble Constant" has variable values in function of τ, we propose that this measure to be called the "Hubble Coefficient".

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The University of Wisconsin
Department of Mathematics
Whitewater, Wisconsin, 53190, U.S.A.
E-mail address: `baicamalvina@gmail.com`

S. C. Herbing S.R.L.
Str. Otetari, 9, Sector 2, Bucharest, Romania
E-mail address: `mircea.cardu@herbing.ro`