



Cyclic Universe Motion in Relativistic Radial Density Theory

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Abstract: In order to describe the New Cyclic Cosmological Motion (NCCM) one can start with the Relativistic Radial Density Theory (RRDT). In this theory Planck's and gravitational parameters can be described as the function of the mass density values. This density is maximal at the minimal gravitational radius and minimal at the maximal gravitational radius. These processes are functions of the radial density values (ρ_r). For the description of the expansion and contraction of the mass objects one needs to know the related radial density value. These values can be described as the function of the mass (energy) constant, κ . Following the previous consideration here it is developed a new dynamics model of the universe motion. This model is the function of the minimal (not zero) radius (with maximal radial density, ρ_{rmax} , and of the maximal (not infinite) radius with the minimal radial density, ρ_{rmin} .

Keywords: cyclic universe motion, mass density, minimal radial density, maximal radial density, minimal radius, maximal radius.

INTRODUCTION

Discussion on the curvature of the space is presented in [1]. The possibility that the world may be with constant negative curvature of the space is discussed in [2]. It follows the presentation of the expansion of the universe with constant mass and increasing radius in [3]. Expansion of the universe, a homogeneous universe of constant mass and increasing radius accounting for the radial velocity of extra galactic nebulae are presented in [4]. Further, in [5-7] it is discussion about the kinematics and world structure of universe. The Milne's theory of world structures is presented by [8]. Discussion about cosmology and particle in astrophysics is pointed out in [9]. The meaning of relativity is presented in [10]. Introduction of Einstein's relativity is consequently discussed in [11]. Ray d'Theory of the six numbers is pointed out in [12]. Initially discussion about cosmic topology is presented in [13]. In [14] it is also pointed out the spatial discussions about cosmological model. Supersymmetry of FRW Baroscopic Cosmologies is presented in [15]. The lectures notes on astrophysics are retrieved in [16].

The cosmological models described by a mixture of der Waals Fluid and dark energy are presented in [17]. Chaos in a Closed Friedmann-Robertson-Walker Universe as an imaginary approach is discussed in [18]. Dark Energy and dark matter from an inhomogeneous dilation is pointed out in [19]. Scale of homogeneity of the universe from WMAP is discussed in [20]. Topological defects: a problem for cyclic universe is present in [21]. Supersymmetry of FRW baroscopic cosmologies is discussed in [22]. Inflationary universe: a possible solution to the horizon and flatness problems is pointed out in [23]. Cosmological models described by a mixture of der Waals fluid and dark energy is presented in [24]. Dark Energy and Dark Matter from an inhomogeneous dilation is discussed in [25]. Further, the Cyclic Universe Models is presented in [26]. Counting voids to probe dark energy

is pointed out in [27]. The large-scale structure of space-time is presented in [28]. Quantum black holes are pointed out in [29].

The simplified cyclic model is presented in [30]. Entropy of contracting universe in cyclic cosmology is pointed out in [31]. Minimum time transition between quantum states in gravitational field is discussed in [32]. Dark matter decay between phase transitions at the weak scale is pointed out in [33]. Search for invisible axion dark matter with the related experiment is presented in [34]. The last five years have seen the coming of age of modern cosmology [35]. In particular, we can now define rather precisely a standard model of cosmology. In that sense the basic parameters are determined within small uncertainties, of just a few percent, thanks to a host of experiments and observations. Cryogenic scintillation properties of n-type GaAs for the direct detection of MeV/c² dark matter is presented in [36].

The actual problems of modern physics, astrophysics, and cosmology has been presented in [37]. The quantization and structure of electromagnetic and gravitational fields are discussed in order to describe of the cyclic motion of the universe [38]. In order to point out of the cyclic motion of the universe it is pointed out the application of the new Relativistic Radial Density Theory (RRDT) in [39]. Modern cosmology, based on the origin and evolution of the universe is presented in [40].

New concepts of dark energy and dark matter thought to constitute the dominant share of the universe were brought to light as a result of these new observations and theoretical ideas. This brief article aims to provide an overview of these exciting developments in the field of cosmology and the associated physics. Progress in physics of the cosmos, including of the dark matter and dark energy, has been presented in detail in [41]. A conventional approach to the dark energy concept is point out in [42] as the constituents in the cosmic fluid. This directly determines the expansion factor appearing in the metric coefficients. As its name suggests, Λ CDM model posits that the energy density is dominated by a blend of dark energy (typically as the cosmological constant, Λ). In a candid assessment of the standard cosmology, presented in [43], it is pointed out a some of the most glaring conflicts between: the standard model, the observations, the several foundational principles in quantum mechanics and general relativity and particle physics. Thus, one cannot avoid the conclusion that the standard model needs a complete overhaul in order to survive.

The so called the topological defects (a problem for cyclic universe) is present in [44]. Further the problem of dark energy and dark matter are presented in detail in [45]. Violations of energy conservation in the early universe may explain dark energy. The topological defects as the problem of the cyclic universe is present in [46] (Avelino P. P., Martins C. J. A. P., Santos C. and Shellard E. P. S. 2003). The problem of dark energy and dark matter is present in detail in [47]. Further, in [48] it is discussed about the tension in the measurements of the Hubble constant. The new Relativistic Radial Density Theory (RRDT) is presented in [49]. In the reference [50] it is pointed out discussion about minimum time transition between quantum states in gravitational field. The novel connection between Planck's and gravitational parameters are presented in [51]. In the references [52] to [60] it is discussed about supersymmetry of FRW, Einstein's relativity, kinematics and world structure, cycles of time and counting voids to probe of dark energy. The cyclic model simplified, dark energy and dark matter from an inhomogeneous dilation, actual problems

of modern physics, astrophysics and cosmology are discussed in [61] to [64]. Finally, in [65] to [67] it is presented the Milne's theory of world structure, principles and application of the general relativity and dark matter and dark energy.

PLANKS AND GRAVITATIONAL PARAMETERS AS FUNCTIONS OF THE RADIAL DENSITY VALUES

To derive the connections between gravitational and radial mass density parameters one can start with the following relations:

$$E=Mc^2, \rho_{rmax}=M/r_{min}=M_p/r_p=2c^2/G, r_p=GM_p/2c^2=r_{min}=GM/2c^2. \quad (1)$$

Here r_{min} is a minimal radius of mass M , r_p is the minimal radius of Planck mass M_p , c is a speed of light in vacuum, G is gravitational constant and ρ_{rmax} is the maximal radial mass density value. The most minimal radius in a gravitational field belongs to the most minimal mass. Since the Planck mass is not the minimal mass in the space-time, the Planck length/radius is not the minimal length/radius in the universe. Further, using Planck mass and Planck length one can calculate the new mass (energy) conservation constant, κ :

$$L_p \frac{2GM_p}{(1+\kappa)c^2}, \kappa = \frac{2GM_p}{L_p c^2} - 1, \kappa = 0.99993392118. \quad (2)$$

From (2) one can see that the new energy conservation constant, κ , is close to one but less than it. This is important discovery that can help in the description of the new dynamic model of the universe motion. Further, it is also important to know the value of the minimal radial mass (energy) density, ρ_{rmin} , in nature:

$$\rho_{rmin} = \frac{M_p}{r_{pmax}} = \frac{M_g}{r_{gmax}},$$

$$\rho_{rmin} = \frac{(1-\kappa)c^2}{G} = 0.888779 \cdot 10^{23} \text{ kg/m}. \quad (3)$$

The presented values for the new mass (energy) conservation constant, κ , in (2) and minimal radial mass densities in (3), respectively, are valid generally and can be applied to the construction (among the others) of the dynamic model of the universe motion. Further, one can introduce of the Planck time, t_p , (as the function of the new energy conservation constant κ) that is defined as the time needed for the light to pass through one Planck length:

$$t_p = \frac{2GM_p}{(1+\kappa)c^3} = \sqrt{\frac{\hbar G}{c^5}}. \quad (4)$$

Following the previous relations, one can derive the related gravitational time, t_g , that is the time needed for the light to pass through one gravitational length:

$$t_g = \frac{L_g}{c} = \frac{L_p}{c} \frac{M}{M_p} = t_p \frac{M}{M_p} = \sqrt{\hbar G / c^5} \frac{M}{M_p},$$

$$M = \rho_{rmin} r_{gmax}, t_g = \sqrt{\hbar G / c^5} \frac{\rho_{rmin} r_{gmax}}{M_p}, \quad (5)$$

Thus, in (5) it is presented the connection between Planck time t_p and gravitational time t_g , as function of the minimal radial mass density, ρ_{rmin} . Further, from the relations

(5), one can conclude that the gravitational time is proportional to the mass. In that sense the minimal time in a gravitational field belongs to the minimal mass. Since the Planck mass is not the minimal mass in space-time, the Planck time is not the minimal time in the universe.

It follows that the minimal energy in a gravitational field belongs to the minimal mass. Since the Planck mass is not the minimal mass in the space-time, the Planck energy is not the minimal energy in the universe. Now one can connect of the Planck temperature T_p and the gravitational temperature T_g as the function of the ratio of the Planck energy E_p and Boltzmann constant k :

$$T_p = \frac{E_p}{k} = \frac{M_p c^2}{k} = \sqrt{\frac{\hbar c^5}{G k^2}}, \quad T_g = \frac{E_g}{k} = \frac{M c^2}{k} = \sqrt{\frac{\hbar c^5}{G k}} \frac{M}{M_p} = \sqrt{\frac{\hbar c^5}{G k}} \frac{\rho_{rmin} r_{gmax}}{M_p} \quad (6)$$

Following (6), one can extend the definition of the gravitational temperature T_g as the function of the minimal radial mass density, ρ_{rmin} . Thus, the gravitational temperature, T_g , is the ratio of the gravitational energy E_g and Boltzmann constant k :

$$T_g = \frac{E_g}{k} = \frac{M c^2}{k} = \sqrt{\frac{\hbar c^5}{G k}} \frac{M}{M_p} = T_p \frac{M}{M_p},$$

$$T_g = \sqrt{\frac{\hbar c^5}{G k}} \frac{\rho_{rmin} r_{gmax}}{M_p}. \quad (7)$$

The relations in (7) presented connection between Planck temperature T_p and the gravitational temperature T_g as the function of the minimal radial mass density, ρ_{rmin} . Further, from (7), one can conclude that the gravitational temperature is proportional to the gravitational mass M , or to the minimal radial mass density, ρ_{rmin} . Thus, the minimal temperature in a gravitational field belongs to the minimal mass. Since the Planck mass is not the minimal mass in the space-time, the Planck temperature is not the minimal temperature in the same region.

Now, following the previous relations one can put together all the connections between Planck's and gravitational parameters. At the first, one can make the connections between Planck length L_p and Planck time t_p with gravitational length L_g and gravitational time t_g :

$$L_g = L_p \frac{M}{M_p} = \sqrt{\hbar G / c^3} \frac{\rho_{rmin} r_{gmax}}{M_p},$$

$$t_g = t_p \frac{M}{M_p} = \sqrt{\hbar G / c^5} \frac{\rho_{rmin} r_{gmax}}{M_p}. \quad (8)$$

It follows the connections between Planck energy E_p and Planck temperature T_p with gravitational energy E_g and gravitational temperature T_g :

$$E_g = E_p \frac{M}{M_p} = \sqrt{\frac{\hbar c^5}{G}} \frac{\rho_{rmin} r_{gmax}}{M_p},$$

$$T_g = T_p \frac{M}{M_p} = \sqrt{\frac{\hbar c^5}{G k}} \frac{\rho_{rmin} r_{gmax}}{M_p}. \quad (9)$$

From the relations (8) and (9) one can conclude to the following permission: all gravitational parameters can be calculated by multiplying of the related Planck's

parameters with the ratio of gravitational mass and Planck mass (M/M_p). In that sense one can use of the applications of previous results to the particle proton. In that sense the proton mass, M_{pr} , is given by the relation:

$$M_{pr} = 1.672622 \cdot 10^{-27} kg. \quad (10)$$

To simplify the related calculations, one can use the maximum six decimals in (10). Applying (10) to the relations (8) and (9) one obtains the following results for the proton:

$$\begin{aligned} L_{gpr} &= 1.242116 \cdot 10^{-54} m, t_{gpr} = 4.143253 \cdot 10^{-63} s, \\ E_{gpr} &= 1.503215 \cdot 10^{-10} J, T_{gpr} = 1.088838 \cdot 10^{13} K. \end{aligned} \quad (11)$$

Now, comparing of the proton gravitational parameters in (11) with the related Planck's parameters one can obtain a very important conclusion: the gravitational length of the proton is less than Planck length. This confirms that Planck length is not the minimal length in space - time, because the minimal length belongs to the minimal mass. Further, the gravitational time of the proton is less than Planck time. This is the consequence of the fact that the gravitational length of the proton is less than Planck length. Generally, one can conclude that all gravitational parameters for the masses less than Planck mass are smaller than the related Planck's parameters. On the contrary, all gravitational parameters for the masses greater than the Planck mass are larger than the related Planck's parameters.

UNIVERSE EXPANSION AND CONTRACTION

As it is the well-known the Friedmann - Robertson - Walker (FRW) metric is given by the relation:

$$ds^2 = - dt^2 + a^2(t) \left(\frac{dr^2}{1 - Kr^2} + r^2 (d\theta^2 + \sin^2\theta d\phi^2) \right) \quad (12)$$

Here K is the constant that determines the possible special curvature of the universe:

$$K = -1 \rightarrow \text{open universe}, K = 0 \rightarrow \text{flat universe}, \quad (13)$$

$K = +1 \rightarrow \text{closed universe}.$

Instead of the relations (13) here it is presented the new mass (energy) conservation constant, κ :

$$\kappa = 0.99993392118. \quad (14)$$

The important consequences of this new constant are:

- a) the universe is closed,
- b) the universe motion is cyclic.

Further, one can start with the estimated total mass of the visible universe, M_u , and radius, r_u :

$$M_u = 1.5 \cdot 10^{53} kg, r_u = 4.4 \cdot 10^{26} m. \quad (15)$$

Using of the new mass conservation constant, κ , one can calculate of the new radial velocity and the radial acceleration of the universe motion:

$$\dot{r} = \pm \left[\frac{2GM}{r} \left(1 - \frac{GM}{2rc^2} \right) + (\kappa^2 - 1)c^2 \right]^{\frac{1}{2}},$$

$$\ddot{r} = \frac{-GM}{r^2} \left(1 - \frac{GM}{rc^2} \right). \quad (16)$$

These relations can be presented as the functions of the minimal radial mass density, ρ_{rmin} :

$$\dot{r} = \pm \left[\frac{2G\rho_{rmin}r_{gmax}}{r} \left(1 - \frac{G\rho_{rmin}r_{gmax}}{2rc^2} \right) + (\kappa^2 - 1)c^2 \right]^{1/2},$$

$$\ddot{r} = - \frac{G\rho_{rmin}r_{gmax}}{r^2} \left(1 - \frac{G\rho_{rmin}r_{gmax}}{rc^2} \right). \quad (17)$$

Using the relations in (17) and the radius $r = GM/c^2$ one can calculate the radial velocity \dot{r} , and the radial acceleration \ddot{r} :

$$\dot{r} = \kappa c = \pm 0.99993392118c, \ddot{r} = 0. \quad (18)$$

From (18) one can see that the maximal expansion (or contraction) velocity is close to the speed of the light but less than it. This is an especially important investigation that confirms the well-known postulation: the nothing can be motion faster than the speed of the light in vacuum.

Using of the numerical values of the parameter, κ , and relation (17) one can calculate of the radial velocity of the universe motion, \dot{r} :

$$\kappa^2 = 0.9998678466, (\kappa^2 - 1)c^2 = -0.0001321534c^2, \quad (19)$$

$$\dot{r} = \pm \left(\frac{2GM}{r} \left(1 - \frac{GM}{2rc^2} \right) - 0.0001321534c^2 \right),$$

At the minimal gravitational radius, the universe expansion velocity and acceleration have the following values:

$$\dot{r} = 0.0001321534c^2, \ddot{r} = \frac{4c^4}{GM} = \ddot{r}_{max}. \quad (20)$$

Thus, at the minimal gravitational radius the initial radial velocity is positive, the radial acceleration is also positive (repulsive) and maximal. This are the necessary conditions for starting with the accelerated expansion of the universe.

Further, at the radius $rc=GM/2c^2$, the velocity and the acceleration of the universe motion have the following values:

$$rc = \frac{GM}{2c^2}, \dot{r}c = \kappa c, \ddot{r}c = 0. \quad (21)$$

Thus, at the gravitational radius rc , radial velocity is maximal, (closed to the speed of the light in vacuum but less than it, because parameter κ is less than one). At the same radius the radial acceleration is equal to zero. For the region where the universe radius is greater than rc , the radial velocity is less than speed of the light in vacuum, c , and the radial acceleration becomes negative (attractive). This are the necessary conditions for starting with further expansion, but now with deceleration. At the same time this also means that the present radius of the universe, r_p , should be between minimal radius r_{min} and radius rc :

$$r_{min} < r_p < r_c = 2r_{min} = L_{gu} \rightarrow$$

$$5.569615 \cdot 10^{25} m < r_p < 1.113923 \cdot 10^{26} m. \quad (22)$$

Since the observed expansion velocity of the universe is close to the speed of the light in vacuum, c , one can conclude that the present gravitational length, L_g , should be close to the universe length, L_{gu} . If the observed universe radius is correct than the present universe mass can be calculated as follows:

$$\frac{M}{L_{min}} = \frac{c^2}{G} \rightarrow M = L_{min} \frac{c^2}{G},$$

$$L_{min} = 2r_u = 8.8 \cdot 10^{26} m, M_{cal} = 11.85 \cdot 10^{53} kg,$$

$$M_{cal} / M_{obs} = 7.9 \approx 8. \quad (23)$$

Thus, the calculated universe mass is about eight times greater than observed universe mass. This means (among the others) that in the calculation of the universe mass one should include the so-called dark mass and dark energy. The second possibility is that the universe radius is bigger than it has been observed.

CONCLUSION

This theory is based on the existence of the maximal and the minimal radial mass (energy) density values. The mentioned radiuses are functions of mass (energy) conservation constant, κ . In that sense the connections of the Planck's and gravitational parameters are presented. As the consequence the gravitational length, time, energy and temperature may be presented as the function of the Planck's length, time, energy and temperature, respectively. The previous connections are based on the existence of the minimal (no null) gravitational radius in the gravitational field. Generally, in the gravitational field there no any singularity. It is because at the minimal gravitational radius there is the maximal radial mass (energy) density which is constant and equal to $M/r=c^2/2G$. Further at this point the gravitation acceleration is positive, gravitational velocity is equal to zero and a gravitational force becomes repulsive. Thus, at the minimal gravitational radius there are satisfactory conditions for starting with the repulsive expansion. The related consequences are that each amount of the mass may have the following: 1) the minimal radius (at the maximal radial mass density) and 2) the maximal radius (at the minimal radial mass density). At the minimal radius there is a maximal radial mass (energy) density. This theory is based on the existence of the maximal and the minimal radial mass (energy) density values. The mentioned radiuses are functions of mass (energy) conservation constant, κ . It is presented that the triplet: ($0 < \kappa < 1$), ($\kappa = 1$) and ($\kappa > 1$) generate, respectively: closed (or cyclic), flat and open universe, respectively. The influence of dark matter and dark energy in the universe motion and the entropy problem in the cyclic motion, will be described in the next manuscript.

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