

# **$\Lambda$ - Toy – Universe model constructed playing with universal constants recognized as fundamental in contemporary physics**

**L. Kostro<sup>1,2</sup>**

<sup>1</sup>full prof. at ATENEUM - University of Higher Education  
Gdansk, Poland

<sup>2</sup>prof. emeritus at Gdansk University, Poland

fizlk@univ.gda.pl

**Abstract.**  $\Lambda$  - natural units determined by the three Einstein's constants:  $c$ ,  $\kappa$  and  $\Lambda$  will be introduced. Some of them are used since long time in GR and Relativistic Cosmology e.g.  $\Lambda$  - centrifugal pressure. Since several years the author of the paper try to introduce the whole set of  $\Lambda$  - units. They will be called  $\Lambda$  - units because they are determined, for the first time, also by the cosmological constant. Among them there is the Mega Quantum of  $\Lambda$  - Action  $H_\Lambda$  that perhaps can be considered as quantization parameter in mega scale: On the occasion of the introduction of  $\Lambda$  - units some human operational ingredients in the technology of creating "natural units" will be stressed out. It will be also indicated that the crucial date in the evolution of our Universe i.e. its expansion acceleration about the 9 billion years after the Big Bang, coincides with the lambda time  $t_\Lambda$ . Since some of  $\Lambda$ -units can be interpreted in de Broglie-like manner it will be asked if there can be introduced a mega scale de Broglie wave mechanics and therefore whether in the Nature there are  $\Lambda$  - mega waves and  $\Lambda$  - mega fluctuations. We can ask also the question whether the unification of the Relativistic Cosmology with QM has to be done rather in the Large Scale (with Mega Heisenberg uncertainty relations) than in the Small Scale. There will be also indicated a possible future mathematical singularity when the percentage of DE will approach 100%.

## **1.Introduction**

In Physics we use conventional standard units of measurements. The most widely used system is the SI one. Physicists like Stoney, Planck, Kittel and others have introduced, into physics of the last two centuries, units that are called "natural units" because they are determined by universal (unconventional) constants which govern our universe and are recognized as fundamental and very important by the scientific community (e.g. Planck constant  $h$  is considered as the basic parameter of quantization in QM especially of elementary particles). In this paper the constant  $H_\Lambda = \frac{1}{c\kappa\Lambda}$  will be proposed as parameter of quantization in mega scale especially in the observably accessible Universe.

### *1.1 Some introductory comments*

*Stoney's Units* [1,2] concern and characterize especially the electromagnetic phenomena. Here they are with their numerical values expressed in the SI system of units:

$$l_s = \left(\frac{Ke^2G}{c^4}\right)^{\frac{1}{2}} = 1.38 \cdot 10^{-36}m; t_s = \left(\frac{Ke^2G}{c^6}\right)^{\frac{1}{2}} = 4.605 \cdot 10^{-45}s; \quad (1)$$



$$m_s = \left( \frac{Ke^2}{G} \right)^{\frac{1}{2}} = 1.86 \cdot 10^{-9} kg \quad (2)$$

and the quantum of action  $h_s = \frac{Ke^2}{c} = 7.704 \cdot 10^{-37} J \cdot s$ , where  $e$  is the elementary unit of electricity discovered and calculated theoretically by Stoney from Faraday's law of electrolysis;  $K = \frac{1}{4\pi\epsilon_0} = 8.99 \cdot 10^9 Nm^2/s^2$  and  $G$  Newton's gravitational constant.

*Planck's Units* [3] concern and characterize especially the quantum phenomena. Here they are introduced by Planck himself with his elementary quantum of action  $h = 6.626 \cdot 10^{-34} J \cdot s$ ;

$$l_p = \left( \frac{\hbar G}{c^3} \right)^{\frac{1}{2}} = 4.05 \cdot 10^{-35} m; t_p = \left( \frac{\hbar G}{c^5} \right)^{\frac{1}{2}} = 1.35 \cdot 10^{-43} s. \quad (3a)$$

$$m_p = \left( \frac{\hbar c}{G} \right)^{\frac{1}{2}} = 5.45 \cdot 10^{-8} kg; T_p = \left( \frac{\hbar c^5}{k^2 G} \right)^{\frac{1}{2}} = 3.55 \cdot 10^{32} K^o \quad (3b)$$

and later by the scientific community with  $\hbar = \frac{h}{2\pi}$ .

$$l_p = \left( \frac{\hbar G}{c^3} \right)^{\frac{1}{2}} = 1.6 \cdot 10^{-35} m; t_p = \left( \frac{\hbar G}{c^5} \right)^{\frac{1}{2}} = 5.4 \cdot 10^{-44} s \quad (4a)$$

$$m_p = \left( \frac{\hbar c}{G} \right)^{\frac{1}{2}} = 2.17 \cdot 10^{-8} kg; T_p = \left( \frac{\hbar c^5}{k^2 G} \right)^{\frac{1}{2}} = 1.41 \cdot 10^{32} K^o \quad (4b)$$

*Kittel's Units* [4] concern and characterize especially the gravitational phenomena and so-called black holes. Ch. Kittel has indicated (or better reminded) that for any given gravitational mass  $m_G$ . its gravitational length, time and mass are given by

$$l_G = \frac{Gm_G}{c^2}; t_G = \frac{Gm_G}{c^3}; m_G = m \quad (5)$$

In Kittel's set of units, the quantum of action for concrete  $m_G$  is given by  $h_G = \frac{Gm_G^2}{c}$  and hence

$$m_G = \left( \frac{\hbar_G c}{G} \right)^{\frac{1}{2}} \text{ and } E_G = \left( \frac{\hbar_G c^5}{G} \right)^{\frac{1}{2}}. \quad (6)$$

where  $m_G$  is the gravitational charge of a particle, of a body, of a star or even of the gravitational matter embedded, according to the standard model, in a Hubble visible sphere. Note that the gravitational length  $l_G$  is in a strict relation with the so-called gravitational radius  $R_G$  called also Schwarzschild radius. In General Relativity we are dealing with three possibilities of  $R_G$ , indicated by S. Weinberg [5]. They depend on the used system of coordinates and metric.

$$R_{G(1)} = \frac{2Gm_G}{c^2}; R_{G(2)} = \frac{Gm_G}{c^2}; R_{G(3)} = \frac{Gm_G}{2c^2} \quad (7)$$

In the case  $R_{G(2)} = l_G$  the metric is expressed in its harmonic form[5]. Note that in all "natural units" the "natural mass and energy" are the mass and energy contained in a Euclidian "box space" (cube) the side of which corresponds to the respective "natural length".

### 1.2 The set of $\Lambda$ - Units

The author has proposed a set  $\Lambda$  of units in previous papers [6-8] that concern and characterize especially Dark Energy (DE) and the phenomena connected with the expansion of the Universe i.e. with anti-gravitational pressure. Their symbols, and how they were introduced will be shown later.

In the present paper the author will introduce a toy-model of some domains of the physical reality in which the Einstein's cosmological constant  $\Lambda$  plays its important and basic part. It is called *toy-model* because the author will *play* with universal constants; They are the *players* in the proposed game. His purpose is primarily to point at some new considerations connected with DE.

Of course, objective problems connected with DE cannot be resolved simply by *playing* only with constants even though they are important. They must be addressed first of all by hard sophisticated mathematical work and by precise observations and experiments.

Let's still add that the play will be done in the framework of the standard model of the universe, So several times equations used in this model will be applied in the paper. The author also takes into account the excellent experimental results obtained in the Great Collider in CERN and the observations of Hubble telescope and the evolving results provided by COBE, WMAP and PLANCK Missions. They cannot be either neglected or omitted when we talk about our universe. *Gedanken-experiments* in which toy-observers will play their part will be used in the paper as well. The dimensional analysis will be applied to deeper intellectual insight into the physical constants used in physics.

## 2. Universal constants as players in the game. How and where do they exist and work?

Are the universal constants real entities or physical processes, or are they only elements of our human mathematical operations and models of the physical reality? As physicists (realists) we must answer the questions because we have to be aware that several kinds of Platonism worked and works in our human physical knowledge. We must be careful to not consider our mathematical models and operations as physical reality. For example, the mathematical model of the hydrogen atom is not a real atom but only our human mental construction that helps us by means of mathematical operations to understand how the real hydrogen atoms exist and work. Analogically our conceptual and imaginative, mathematical and geometrical models of the Universe are only our mental constructions that help us to understand its existence and activity. They concern our Universe but are not its constitutive elements.

Nevertheless, the mathematical models are very powerful and important tools that help us to describe the physical Reality. In Physics we are using conventional units, e.g. nowadays the SI system. As was already mentioned some physicists have introduced the so-called "Natural Units" determined by universal constants that govern in our human descriptions of the universe and are recognized as fundamental and very important. However, we must be aware that the so-called universal constants are not free from human operations. We use them in our descriptions of Nature, they concern Nature but they are at the same time our mental operational tools. Nature does not depend upon our mental operations but these human operations concern Nature. The human ingredient of universal constants will be stressed out in this paper.

### 2.1 Let's begin with the constant $c$ - "constant velocity of light in vacuum"

It indicates that in the real world the transfer of momentum and energy cannot be greater than  $c$ . The velocity of light in vacuum is the best example of such a limitary transfer of momentum and energy. But how do we introduce the physical quantity "velocity" (and quantities connected with it e.g. momentum and energy) into our models of the physical reality at all? We do it by a mathematical operation. We divide the path along which a body moves by the time in which it moves and we express it in conventional units a meter per second. We do it because we are existentially interested how many meters e.g. a quantum of light runs pro second. But there are real existential situations in which we are existentially interested in the opposite operation. We would like to know e.g. how many times we need to arrive from our house to the bus stop. In such a cause we do an opposite mathematical operation we divide the time interval by the distance. We say then that we use 15 minutes to overcome the spatial distance from our house to the bus stop. Note that real physical processes like e.g. a light ray is not interested whether we human beings divide spatial distance by time interval or we do the opposite. Then, in the case of light we have to say light uses one second to overcome the distance of 299,792.458 meters. In such a way we see clearly that there are human

ingredients and operations in defining physical quantities. The velocity  $c$  is such a human ingredient that concerns, however, the investigated reality. It shows only an aspect of the real transfer of energy and momentum. But we have still to be careful because in the definitions of momentum and energy the velocity plays an important part. Momentum  $= mv$  or  $mc$ , energy  $E = mc^2$  or e.g. or  $mv^2/2$  in classical mechanics. As we can see, physics, in his operational definitions of physical quantities, prefers more the operation of dividing the path by time unit than the division of time interval by length distance. Note that  $c^2, c^3, c^4, c^5 \dots$  play also their parts in physics. For example,  $-c^2$  indicates the greatest limitary scalar gravitational potential and  $c^2$  indicates the constant energetic potential of DE. Note that the path and time intervals are determinate in many cases by measuring operations. Here is the contact with reality. So, in determining constants measuring operations are included and necessary.

## 2.2 The constant $G$

$G$  is the mathematical coefficient introduced by Newton to connect his gravitational force  $F = mg$  with two gravitationally interacting charges  $m$  and  $m$  inversely to the square of distance  $\frac{1}{R^2}$ ,  $F = mg = \frac{Gm^2}{R^2}$ .

The ratio  $\frac{m^2}{R^2}$  has not the dimension of a Newtonian force. To receive such dimensions, we have to multiply it with the coefficient  $G$ .

Note, however, that its inverse  $\frac{1}{G} = 1.498 \cdot 10^{10} \text{ kg m}^{-3} \text{ s}^2$  has a specific physical meaning in GR. The dimensional analysis of it shows that it is a product of mass density  $\varrho = \frac{m}{l^3}$  and the square of time  $t^2$ . Hence  $\frac{1}{G} = \frac{m}{l^3} t^2 = \varrho t^2$ . For example, in the mentioned above Stoney's, Planck's and Kittel's Units we are dealing with the following relations:

$$\varrho_P t_P^2 = \varrho_S t_S^2 = \varrho_G t_G^2 = \frac{1}{G} = 1.498 \cdot 10^{10} \text{ kg m}^{-3} \text{ s}^2 \quad (8)$$

Note that the relation between density and time square has also a real physical meaning in the whole Universe represented in Friedman's equations therefore let's stress out the part played by the relation mass density and square time  $\frac{1}{G} = \frac{m}{l^3} t^2 = \varrho t^2$  in the standard model of the Universe in which it is assumed that  $\Lambda > 0$  and its geometry is flat and therefore its curvature parameter  $k = 0$ . The product  $\varrho t^2$  is contained as a basic mathematical structure in Friedman equations in the standard model in which on the base of recent observations and theoretical consideration the age of the Universe is estimated to be  $T_{H_0} = \frac{1}{H_0} \sim 13.819$  billion years [9]

The Friedman equation of the model with  $k = 0$  and  $\Lambda > 0$  has the following form

$$(8\pi G \varrho_G / 3) + (\Lambda c^2 / 3) - H^2 = 0 \quad (9)$$

(where  $\varrho_G$  is the average mass density of the gravitational ponderable matter (GPM) and  $\Lambda c^2$  is the raised to the second power inverse of the  $\Lambda$ -time  $t_\Lambda = 1/c\Lambda^{1/2}$  as we will see later)

In the standard model the average mass density  $\varrho = \varrho_G + \varrho_\Lambda$  in the universe is considered to be equal to the so-called time depended critical density  $\varrho_{crit}$ . It means that

$$\varrho_{crit} = \frac{3H_0^2}{8\pi G} \text{ and } = \frac{3}{8\pi G T_0^2} \quad (10)$$

because in the standard model the Hubble parameter  $H_0 = \frac{1}{T_{H_0}}$ . The average mass density is considered as the sum of the average mass density of the GPM  $\varrho_G$  and the mass density  $\varrho_\Lambda$  of lambda mass corresponding to DE density.

$$\varrho = \varrho_G + \varrho_\Lambda = \varrho_{crit} = \frac{3H_0^2}{8\pi G} = \frac{3}{8\pi G T_0^2} \sim 9,46 \cdot 10^{-27} \text{ kg/m}^3 \quad (11)$$

Consider that we use in the considered model also the dimensionless density parameters  $\Omega_G = \rho_G / \rho_{crit}$ ;  $\Omega_\Lambda = \rho_\Lambda / \rho_{crit}$  related between them as follows  $\Omega_G + \Omega_\Lambda = 1$ . Before Planck Mission on the basis of the observational WMAP 7-year results:  $\Omega_\Lambda = 0,728 \pm 0,016$  and  $\Omega_G = 0,272 \pm 0,016$ . It indicates that according to the 2015 WMAP results there is about 72% of DE and about 28% of GPM. But after PLANK Mission the percentage is more precise: 68 - 69% of DE and 31- 32% of GPM [9].

Which is the relation between the present-day critical density  $\rho_{crit}$ , and the present-day square age of our Universe  $T_0^2$ ? Is it equal to  $\frac{1}{G}$ ? The  $\frac{1}{G}$  enters in the relation but with a dimensionless coefficient. Here it is:  $\rho_{crit} T_0^2 = \left(\frac{3}{8\pi}\right) \frac{1}{G}$ ; The dimensionless coefficients for  $\rho_G T_0^2$ ,  $\rho_\Lambda T_0^2$  and also  $\rho_\Lambda t_\Lambda^2$  have their own dimensionless coefficients used in GR. When the age of the universe was equal to  $t_\Lambda$  then the coefficient was  $\left(\frac{1}{8\pi}\right)$ . Therefore we write  $\rho_\Lambda t_\Lambda^2 = \left(\frac{1}{8\pi}\right) \frac{1}{G}$ . As we will see later  $\left(\frac{1}{8\pi}\right)$  can be considered as the coupling constant between gravitational and anti-gravitational lambda interactions. Note that we can maintain that we deal with two constants  $G$ : the first is connected with the GPM (Dark Matter + Ordinary /Barionic Matter)  $G = 6,67408 \cdot 10^{-11}$  that plays its part in the curving and attracting activity in the GR theory and with the second  $G_\Lambda = 8 \pi G = 1.677329736 \cdot 10^{-9}$  that plays its part in straightening up and repulsive/expanding activity. Therefore, we are dealing in reality also two kinds of “force”: the gravitational limitary “attractive force”  $F_G$  and the lambda “repulsive force”  $F_\Lambda = F_G / 8 \pi$ .

### 2.3 The constant $\kappa = 8\pi G c^{-4}$

Sometimes called Einstein’s gravitational constant, is the coefficient that is a component of his General Relativity equation. It has the dimension of an inverse force, as was already indicated, of the “lambda force”.

As well known in GR we do not speak about gravitational force. Gravitation is considered as the result of the curvature of space – time. However, the GR equation contains in itself a force  $\frac{1}{\kappa}$  in a hidden way that plays its part in centrifugal pressure to avoid the gravitational collapse. This pressure consists in the acting of the “lambda force”  $\frac{1}{\kappa}$  on an inverse surface that is just lambda  $\Lambda$ . So, we see that the “force”  $\frac{1}{\kappa}$  is not a “gravitational force” but “the  $\Lambda$ -force”. It is present in the action Lagrangian

$$S = \int \left[ \frac{1}{2\kappa} (R - 2\Lambda) + \mathcal{L}_M \right] \sqrt{-g} d^4x$$

Consider that from this Lagrangian can be derived the Einstein’s equation of GR with  $\Lambda$ , applied by him to the whole universe.

### 2.4 The $\Lambda$ constant

As it is well known Einstein introduced the cosmological constant  $\Lambda$  in 1917 when he applied his GR field equation to the whole universe.  $\Lambda$  was introduced into this new theory in order to avoid a gravitational collapse of the universe. Einstein was aware that he had to introduce a “centrifugal repulsive pressure” of the physical vacuum to regain an equilibrium in the Universe. Einstein has not indicated any numerical value of his cosmological constant. Step by step after Hubble discovery of the expansion of the universe and after construction of many models of it we began to talk about the pressure of the physical vacuum. To have an insight into the notion of vacuum pressure let’s study some details. If we let  $P$  represent Pressure and  $F$  a Force, acting on a surface having a certain  $A$ , then  $P$  is given by  $P = \frac{F}{A}$ . So, in order to find  $P$  we need (i) a force and (ii) an inverse area  $P = F \frac{1}{A}$ . Let us now see how we can introduce in GR a “repulsive force”. It is well known that in GR we do not speak about a “gravitational attractive force”. Gravitation is considered as the result of the curvature of space–time. Gravity is considered as embedded in the geometry of space time. The deformations of space-time, however, are caused by the presence of the masses of the GPM.

However, as was already mentioned, the GR equation contains, in a hidden way a “force”, in the

constant  $\kappa = \frac{8\pi G}{c^4}$ . The constant  $\kappa$  has the dimension of an inverse force. In order to introduce the “centrifugal pressure” as the “repulsive force” the inverse of  $\kappa$  was chosen. It means that the “repulsive force” is the “lambda force”  $F_\Lambda$  that is given by

$$F_\Lambda = \frac{1}{\kappa} = \frac{c^4}{8\pi G} = 4.815 \cdot 10^{42} \text{ N} \quad (12)$$

Physicists do not like the name “repulsive force.” They prefer to say that  $\Lambda$ , as an inverse surface, is embedded in the geometry of space-time and so it causes anti-gravitational repulsion like the curvature of space-time causes gravitational attraction. Accordingly, we can think of  $\Lambda$  as straightening up the space-time that becomes curved by the presence, by the impact of GPM. Cosmologists, however, needed still a constant surface on which the “lambda force” acts to obtain the needed pressure. This constant is called “cosmological” and has the dimension  $m^{-2}$  (meter raised to the minus second power). It is extremely small. Taking into account the results of PLANCK Mission (2013) [9]:  $\Omega_\Lambda = 0.6825$  and  $T_o = 13.819$  billion years the numerical value of the cosmological constant is estimated to be approximately:

$$\Lambda = (3\Omega_\Lambda / T_o^2 c^2) \sim 1.197 \cdot 10^{-52} m^{-2} \quad (13)$$

Considering the “lambda force”  $\frac{1}{\kappa}$  and the “inverse surface” (i.e.  $\Lambda$  itself) we see that the “repulsive lambda pressure” introduced by Einstein’s followers is given by

$$P_\Lambda = \frac{\Lambda c^4}{8\pi} = \frac{\Lambda}{\kappa} \sim 5.77 \cdot 10^{-1} \text{ N} \cdot m^{-2} \quad (14)$$

Measured in a human scale, it is very weak

Let’s conclude the introduction of players of the game with the statement: the universal constants although they are elements of human models, they concern the objective reality and are very important. The scientific community recognizes their importance, because to determinate them also measuring operations are included.

### 3. Data concerning Einstein’s physical space-time as the one and only with an energy density (currently called Dark Energy density)

Einstein’s ideas concerning space-time, especially during the period 1905-1938, changed several times. I presented in details the evolution of his opinions in my book *Einstein and the Ether* [10] and in a very abbreviated way in the paper, *The evolution of Einstein’s ideas concerning ether space and time* [11]. The shortest history is the following: Einstein, some years before his Special Relativity (SR) 1905 paper, under the impact of Paul Drude began to consider as ether the objective space having real physical properties i.e. he identified the ether with the space of our universe. When he arrived, in the mentioned 1905 paper, to the conclusion that the Newtonian absolute space with the attributed to it stationary features does not exist he abolished together with it the stationary ether of XIX century physics as superfluous. When formulating his General Relativity (GR) he arrived to the conclusion that the GR space and time do not exist because in GR the space-time coordinate systems are only artificial geometrical networks, he denied the existence of space and time at all and considered the physical reality exclusively as a set of physical events. But when Lorentz in a letter to Einstein tried to convince him that physical space-time has physical properties of an stationary ether Einstein again rejected the stationary ether but arrived, after a deeper reflection, to the conviction that Space-time really exists because it has real physical features described in GR by the components of the metrical tensor  $g_{\mu\nu}$  and so he reintroduced the physical Space-time into his theory and together a non-stationary ether that he called “new” in opposition to the stationary which he began to call “old”. When Einstein, because of Lorentz’s letter, became aware that his relativistic space-time has real properties indeed, then he began

to maintain that they are described by the components of the metrical tensor  $g_{\mu\nu}$ . Replying to Lorentz [12] he wrote the equation  $\text{Ether} = g_{\mu\nu}$  almost unknown by the majority of physicist. So, the terms ether, space and also field became synonyms for Einstein. He published some papers concerning his new opinions entitled e.g. *The Problem of Space, Ether and Field in Physics* [13].

In the next years the founder of Relativity Theory made a clear distinction between the called by him *Physical Space-time as such or as the whole* and the *Reference Space-times*. According to him the *Physical Space-time as such* is one and single but the number of *Reference Space-times* is countless. We can introduce an infinite number of inertial observers with their proper reference space-times.

To be clear as possible Einstein made first an artificial distinction between the three-dimensional space and one-dimensional time that are interconnected in his theory and have to be treated together. So, he made first a distinction between the single *Physical Space as such or as the Whole* (der physikalische Raum als solche oder als Ganze) and the *Reference Spaces* (die Bezugsräume). According to him the *Physical Space as such* is not composed of geometrical points or physical particles and therefore it is also not composed of space intervals because as not composed of points cannot be divided into parts. As well we cannot say either that it moves or it is at rest. We can only say it is a continuum. The notions of motion and rest are inapplicable to the *Physical Space as such*. However, they can be used with respect to the countless *Reference Spaces*. Let's explain Einstein's ideas using an countless number of one-dimensional straight lines that moves with respect to each other in two directions left/right with velocities not greater than  $c$ . Each straight line, into consideration, is composed of points and can be divided into parts. They can serve as reference spaces. But there is still a container of these straight lines that is one and only and enables the lines to move in it. They move in this container that is a continuum but is not composed of points and not divisible in parts. To this continuum the notions of motion and rest cannot be applied. But it exists and is a container that enables the motion of the straight lines. The container cannot serve as a privileged reference frame. Otherwise the principle of relativity of the Theory of Relativity would be violated. The real *Physical Space as such* is a three-dimensional continuum that enables the motion of the three-dimensional reference spaces with respect to each other but not with respects to the three-dimensional container. Concluding we can state: The *Physical Space as the Whole* contains in itself a countless number of the *Reference Spaces* that move in it with respect to each other but we cannot say either that they move or not move with respect to the *Space as such* which is not composed of points.

Similar features have to be attributed to the *Physical Time as such* that is one and only. The reference times are countless. Every reference space has its proper time composed of moments and divisible in time intervals counted by their proper clocks. However, the *Physical Time as such* is not composed of moments and indivisible into time intervals. As well we cannot say either that the *Time as such* flows or does not flow. The notions of time flowing or not flowing cannot be applied to it. However, it simply exists and enables the flowing of all reference times. The distinct presentation of space as such and time as such Einstein [14] called "dynamic image" of them.

Einstein presented also his ideas omitting the artificial separation of time with respect to space. He called such a presentation "static image" [14]. In this image i.e. in his space-time description to the space-points correspond world-lines and to the time moments three-dimensional momentary spaces. In such a presentation according to Einstein the *Physical Space-time as such* is not composed of world-lines and of three-dimensional momentary spaces. The *Physical Space-time as such* is according to Einstein, ultra-referential or perhaps better trans-referential and enables the existence of the countless referential space-times. Let's quote Einstein to better comprehend his ideas concerning the trans-referential space-time. In the quotation, as we will see, are present the two shown above images of space-time as such the dynamic and the static one [14].

One can imagine that extended physical objects exist to which the idea of motion cannot be applied. They are not to be conceived as composed of particles, whose course can be followed separately through time. In Minkowski language this is expressed as follows: Not every extended entity in the four-dimensional world can be regarded as composed of world-lines. The special principle of relativity forbids us to assume that the ether consists of particles observable through time but the

ether hypothesis in itself is not in conflict with the special theory of relativity. However, we must take care not to ascribe a state of motion to the ether [15].

Every physicist knows Minkowski diagrams of SR space-time. A single Minkowski diagram as a whole presents the space-time as such that is one and single. The presented in the diagram time axes  $ct'$ ,  $ct''$ ... represent the reference times in a form of world-lines and the space axes  $x',x''$ ...or  $y'y''$ ... or  $z'z''$ ... present the reference spaces in the form of the three-dimensional momentary spaces. They are present in the diagram and represent the reference space-times but they do not represent the space-time as such that is not composed of reference space-times but it is a container that enables the existence of reference space-times

The *Physical Space-time as such* simply exists and has an energy density. It has neither a beginning nor an end. It is never absent but ever present. It is the basic physical background. Einstein uses often instead “physical” the word “ontological”. The above quotation concerns not only SR to which are applied Minkowski diagrams. In GR the problem of a one and single *physical space-time as such* is more sophisticated because of taking into account also the acceleration fields, but the main idea is the same the *Physical Space-time as the Whole* is the common container of all kinds of *Referential Spaces*. According to Einstein the SR space-time as such is described by the components of the symmetric metric tensor  $\eta_{\mu\nu}$  Ether =  $\eta_{\mu\nu}$  like in GR Ether =  $g_{\mu\nu}$  The components of  $\eta_{\mu\nu}$  are constant. Instead the components of the metrical tensor  $g_{\mu\nu}$  are used by an observer describing space-time as such from GR reference spaces. In areas in which space-time is flat we use  $\eta_{\mu\nu}$ .

As we could see General Relativity (GR) introduces more sophisticated data. It introduces reference spaces in which we are dealing with acceleration fields. Gravitational attraction causes acceleration because of bodies having mass that are curving space-time. We deal with acceleration fields also, in accelerated cabins.

Note, however, that in GR gravitation is considered as a tensor-field. We describe the deformations (the curvature) of space-time using the components of the metric tensor  $g_{\mu\nu}$ . When we deal with regions that are not deformed by great masses, we use the tensor  $\eta_{\mu\nu}$  but when we talk about DE it is maintained that we deal with a scalar-field. Energy as physical quantity is a scalar. Also, the mass, corresponding to energy, is a scalar.

According to Einstein the *Physical Space-time as such* is not empty. It has a density of energy. Hence, according to him, it should be not called vacuum but plenum. We call today this space-time as such energy Dark Energy (DE). Perhaps Einstein would prefer the denomination “Divine Energy” because his *Ontological Space-time as such* is never absent but ever present. As regards space-time energy density its mathematical form is since longtime used in the relativistic cosmology:

$$\rho_{(DE)\Lambda} = \frac{\Lambda c^4}{8\pi G} = \frac{\Lambda}{\kappa} \sim 5,77 \cdot 10^{-10} \text{ J} \cdot \text{m}^{-3} \quad (15)$$

Since it is determined by constants it is also constant. Note that it is constant with respect to all reference spaces like its other many features. Space-time as such is an ultra-referential or perhaps better a trans-referential entity. So, its features determined by universal constants are constant. The physical space-time as such is flat (not curved) by its nature and opposes itself against any curving deformation. So, we can say, it opposes itself against such deformations with the lambda pressure. Its mathematical form is also since longtime used in the relativistic cosmology (see eq. 14)

It is when physical space-time as such becomes curved, because of the strong impact of great concentrations of the ponderable matter (represented according to new investigations by Dark Matter + Normal Matter), that curved space-time becomes a gravitational field. Gravitational fields appear in the neighborhood of the concentrations of the ponderable matter. Over great distances they disappear. When the physical space-time as such remains flat then it is considered as inertial field. The motion of a test particle cannot be detected in it. The curved parts of the physical space-time as such tends to become rectified. That's the anti-gravitational activity of DE. The gravitational fields are local but DE is everywhere. It is not composed of particles and never has rest mass. When physicists speak about



DE mass density and write the mathematical formula of this density (used already since long time in relativistic cosmology) then they talk about the mass density that corresponds to the space-time energy density.

$$\varrho_{\Lambda} = \frac{\Lambda c^2}{8\pi G} = \frac{\Lambda}{\kappa c^2} \sim .642 \cdot 10^{-2} \text{ kg} \cdot \text{m}^{-3} \quad (16)$$

In our human scale they are very weak  $\varrho_{\Lambda} \sim 10^{-27} \text{ kg} \cdot \text{m}^{-3}$  and  $\varrho_{(DE)\Lambda} \sim 10^{-10} \text{ J} \cdot \text{m}^{-3}$ . Some properties of the Dark Energy are considered by cosmologists as constant among them just its density of mass and of energy.

The lambda pressure  $P_{\Lambda}$  is known since long time in Relativistic Cosmology, but the majority of lambda units that the author tries to introduce are unknown.

#### 4. Toy-point-observers with numerous eyes looking in all directions

Like Boltzmann has introduced his demon and Schrödinger his cat let us introduce toy-point-observers that exist in every point of our universe from the beginning and have numerous eyes looking in all directions with respect to the horizon. Since his eyes look in all directions simultaneously, therefore he has one global past light cone. Each toy-point-observer has his own sphere of observation, his visible sphere, his field of vision. Such a visible sphere is not only his global past light cone but also it is his proper reference space-time, his proper cosmic space-time the horizon of which runs away from him with the velocity  $c$ . The toy-point observers will serve to us as participants in our *Gedanken-experiments*. The background radiation (CMB) is seen in each visible sphere of toy-observers as their visible horizon. Their visible universes are spherical volumes (babbles spaces) centered on a toy - observer. Every location of a toy observer in the Universe has its own visible universe, which may or may not overlap with the one centered on Earth. The radius  $R_o$  of each visible sphere increases with time. The present day  $R_o$  is for each observer about 13.819 billion light years long. Each visible sphere is a babble-space causally bounded because of the limitary velocity  $c$  of interactions. In the expanding space of the Universe the causally bounded observation spheres can touch or partially cover (overlap) each other or be separated. Since according to the standard model space-time is flat in the large scale therefore each increasing with time visible sphere is for a point toy-observer approximately an Euclidian sphere and his proper inertial reference space which is at rest or move with respect to the background radiation that being a material medium is a reference space.

When we “turn back our clocks” then we can imagine the past. The visible spheres would become smaller and smaller and the toy-point-observers would be closer and closer to each other. But there are minimal limitary distances between them. In Planck’s system of units, the Planck length is such a limitary distance. The so-called Planck’s area begins with such distances among the point-toy-observers.

Cosmologists has introduced also another observable sphere called Hubble sphere in which it is shown how far the observed galaxies are really now, i.e. at the present moment. The edge of the observable universe conceived in such a way is about 46.5 billion light years away. So, the diameter of the Hubble sphere is about 93 billion light-years long.

Note that in the technology of introducing “natural units” we do not use “bubble spaces” but “box spaces”. In such a case the volume unit is considered as an Euclidian cube the side of which is the length unit. In the case of Planck’s units, we use very tiny cubes with sides equal to Planck’s length that is extremely small and in the case of  $\mathcal{A}$  - units, mega cubes with sides that are extremely great.

#### 5. The Lambda Units determined by three Einstein’s constants $c$ , $\kappa$ and $\mathcal{A}$

In order to introduce the whole set of  $\mathcal{A}$  - Units we have to use the dimension analysis and the same mathematical technology that was used by Stoney, Planck and others. First of all we need the three fundamental lambda basic units determined in our case by the 3 mentioned Einstein’s constants:  $c$ ,  $\kappa$ , and  $\mathcal{A}$ : the lambda length -  $l_{\Lambda}$ , the lambda time -  $t_{\Lambda}$  and the lambda mass -  $m_{\Lambda}$ . Let’s look for them. Since lambda is an inverse area  $\mathcal{A} = \frac{1}{\Lambda}$  therefore the lambda area is given by  $A_{\Lambda} = \frac{1}{\Lambda} = 8.35 \cdot 10^{51} \text{ m}^2$ .

Note that it is extremely large.

The  $A_\Lambda$  can be considered as an immense square with a side equal to lambda length. We find that  $l_\Lambda = \sqrt{A_\Lambda} = \frac{1}{\Lambda^{1/2}} \sim 9.14 \cdot 10^{25} \text{ m}$  is  $\sim 9.66$  billion light years

As we can see the  $l_\Lambda$  is extremely long, especially in comparison to the Planck length which is extremely short  $l_p = \left(\frac{\hbar G}{c^3}\right)^{1/2} = 1.6 \cdot 10^{-35} \text{ m}$ .

Also, lambda time is an extremely long time interval:

$$t_\Lambda = \frac{l_\Lambda}{c} \sim 3.048 \cdot 10^{17} \text{ s} \quad t_\Lambda = \frac{l_\Lambda}{c} = \frac{1}{c\Lambda^{1/2}} \sim 9.66 \text{ billion years} \quad (17)$$

We need still to find the lambda mass  $m_\Lambda$ . For many years in GR and relativistic cosmology the quantity “lambda mass density” was used:  $\varrho_\Lambda = \frac{\Lambda c^2}{8\pi G} = \frac{\Lambda}{\kappa c^2} \cdot 45 \cdot 10^{-27} \text{ kg m}^{-3}$

For mass is a product of density and volume we need still the lambda volume that is given by

$$V_\Lambda = l_\Lambda^3 \sim 7.62 \cdot 10^{77} \text{ m}^3 \quad (18)$$

Multiplying (16) and (18) we receive (19)

$$m_\Lambda = \varrho_\Lambda V_\Lambda \sim 4.89 \cdot 10^{51} \text{ kg} \quad (19)$$

(Note that  $V_\Lambda$  is a Euclidian “box-space” (cube) the side of which is equal to  $l_\Lambda$ . So, the  $m_\Lambda$  is the mass that is contained in the mentioned Euclidian box-space).

We now have already the fundamental three  $\Lambda$  Units:  $l_\Lambda$ ,  $t_\Lambda$  and  $m_\Lambda$  and all of them are extremely large!!! Remember that lambda mass of DE is not a rest mass. It is used only as numerical value that corresponds to space-time energy because of the relation  $E=mc^2$

$$E_\Lambda = m_\Lambda c^2 = \frac{c^4}{8\pi G\Lambda^{1/2}} = \frac{1}{\kappa\Lambda^{1/2}} \sim 4.39 \cdot 10^{68} \text{ J} \sim 2,743 \cdot 10^{78} \text{ GeV} \quad (20)$$

Among lambda units there is also the *Mega Quantum of Action*

$$H_\Lambda = \frac{1}{c\kappa\Lambda} \sim 1.34 \cdot 10^{86} \text{ J} \cdot \text{s} \sim 8.36 \cdot 10^{95} \text{ GeV s} \quad (21)$$

According to our present day knowledge our universe is flat at least in the scale of our visible sphere and therefore we can use with great approximation to such a sphere the Euclidian equation  $V = (4/3)\pi R^3$ . So, when the age of the universe was equal to the  $\Lambda$  - time the  $\Lambda$  - sphere volume was  $S_\Lambda = \frac{4\pi}{3[(\Lambda^2)^3]} \sim 3.19 \cdot 10^{78} \text{ m}^3$ .

So, the first  $\Lambda$  - Bubble of DE comes into play. Let's calculate the numerical value of its mass and energy. The lambda mass  $m_{\Lambda 2}$  in a lambda visible sphere  $S_\Lambda$  (i.e. in the field of vision of the toy-observer, in his Bubble sphere is given by  $m_{\Lambda 2} = \varrho_\Lambda S_\Lambda \sim 2.58 \cdot 10^{52} \text{ kg}$ .

Then the lambda energy  $E_{\Lambda 2}$  in a lambda visible sphere  $S_\Lambda$  (in the  $\Lambda$  -Bubble of DE) is given by  $E_{\Lambda 2} = \varrho_{(\text{DE})\Lambda} S_\Lambda \sim 2.32 \cdot 10^{69} \text{ J}$ .

Let's Consider that  $m_\Lambda$  and  $E_\Lambda$  mean the quantity of DE mass and energy that are contained in a Euclidian cube (box-space) the side of which is the lambda length. The basic units have such properties. For example, Planck mass and energy are quantities of mass and energy that are contained in a very tiny Euclidian cube (box-space) with the side equal to Planck's length. The  $m_{\Lambda 2}$  and  $E_{\Lambda 2}$

indicate the quantity of DE mass and energy in an Euclidian lambda sphere (bubble-space) with a radius  $l_\Lambda$  in which there is 33% of DE and 66% of GPM at the age of the universe equal to  $t_\Lambda$ .

## 6. Lambda units can be written in a Planck-like form

Note that we can write the lambda units in a Planck like form when we will use the three constants  $c$ , the anti-gravitational constant  $G_A = 1.677329736 \cdot 10^{-9}$  and the Mega Quantum of Action  $H_\Lambda$ . Here they are:

$$\begin{aligned} l_\Lambda &= \frac{1}{\Lambda^{1/2}} = (H_\Lambda G_A / c^3)^{1/2} \sim 9,14 \cdot 10^{25} \text{ m} \\ t_\Lambda &= \frac{1}{c \Lambda^{1/2}} = (H_\Lambda G_A / c^5)^{1/2} \sim 3,048 \cdot 10^{17} \text{ s} \\ m_\Lambda &= (1/c^2 \kappa \Lambda^{1/2}) = (H_\Lambda c / G_A)^{1/2} \sim 4,89 \cdot 10^{51} \text{ kg} \\ \varrho_\Lambda &= \frac{\Lambda}{\kappa c^2} = (c^5 / H_\Lambda G_A^2) \sim 6,42 \cdot 10^{-27} \text{ kg} \cdot \text{m}^{-3} \text{ and so on} \end{aligned}$$

So, the lambda units are also determined by  $H_\Lambda$ . Does it mean that  $H_\Lambda$  has to be considered as quantization parameter for DE? Note that in the Planck like forms the cosmological constant  $\Lambda$  remains, in a hidden way, in the Mega Quantum of Action  $H_\Lambda = \frac{1}{c \kappa \Lambda}$ .

## 7. Highlighting an interesting coincidence. Reasons indicate why a so-called 2nd inflation

Every point in the universe from which the universe becomes “visible” when we connect with it “a toy-point-observer” is the center of the centrifugal pressure that is the source of the expansion of the universe in all directions. So the point in which is a toy-point-observer is the center from which DE repels the GPM.

The accelerating expansion of the universe manifests itself in the observation that the universe expands at an increasing rate meaning that the velocity at which a distant cluster of galaxies is receding from the observer is continuously increasing with time.

The accelerated expansion of the universe was discovered in 1998. Cosmologists expected that the expansion should be decelerating due to the gravitational attraction of the matter in the universe. The observations have proved the opposite.

It is estimated that the second inflation began roughly about 9.5 billion years after the Big Bang. So the expansion of the universe is thought to have been accelerating since the universe entered its dark energy dominated era roughly about 4.5 billion years ago.

Let's now highlight the very interesting coincidence by means of three statements:

1. When our universe was roughly about 9.66 billion years old, when the lambda time became real, then the second inflation of our universe began. Our universe because of the repulsive pressure of Dark Energy began an accelerated expansion.
2. At that time, when the real radius of our visible universe became about 9.66 billion light years long, i.e. when the lambda length became real, indeed then our universe began an accelerated expansion.
3. At that crucial time around 96.6 billion years after the Big Bang also the real Mega Quantum of Action  $H_\Lambda$  appeared and became activated and so it began to play its part in the expansion of our Universe. Perhaps DE creates a new fundamental “force” in the universe, something that only starts to show an effect when the universe reaches a certain space-time size
4. Note that Dark Energy has a constant density. Dark Energy is considered (in majority of its theories) simply as *a property of space itself*, and as such it would not be diluted as space expands. As more space-time comes into the visible sphere of a toy observer, the more energy-of-space-time would simply appear! And cause the Universe to expand faster and faster!

So, note that in general, in the Dark Energy theories, the density of the Dark Energy  $\varrho_{DE\Lambda}$  and the corresponding density of lambda mass (that is not a rest-mass)  $\varrho_\Lambda$  are considered as constant  $\varrho_{DE\Lambda} = \frac{\Lambda c^4}{8\pi G} = \frac{\Lambda}{\kappa} = \text{constant}$ ;  $\varrho_\Lambda = \frac{\Lambda c^2}{8\pi G} = \frac{\Lambda}{\kappa c^2} = \text{constant}$ .

Among the constant  $\Lambda$  - units there are not only the above-mentioned densities but also the  $\Lambda$ -Mega Quantum of Action

$$H_{\Lambda} = \frac{1}{c\kappa\Lambda} \sim 1.34 \cdot 10^{86} J \cdot s \sim 8,36 \cdot 10^{95} GeV \cdot s \quad (22)$$

and the  $\Lambda$  - Mega Quantum of Angular Momentum

$$H'_{\Lambda} = \frac{1}{2\pi c\kappa\Lambda} \sim 2.17 \cdot 10^{85} J \cdot s \sim 1.35 \cdot 10^{95} GeV \cdot s \quad (23)$$

QUESTIONS:

- (1) They are esthetically appealing but do they have any physical meaning in the large-scale world?
- (2) Does anything correspond to them in the large-scale physical reality?
- (3) Can  $H_{\Lambda}$  serve as a real quantization parameter in the mega scale?
- (4) Can we attribute a spin to the non-constant  $\Lambda$ - energy quanta? Note that when the calculus of variations was introduced, it became clear that action can have extremal values. Perhaps it is quantizable not only in the micro scale but also in the large scale.

Nevertheless, we have to accept the age of our Universe, when it reached about 9.66 billion years after the Big Bang, as a crucial date i.e. as beginning of ED dominating era.

#### 8. Proportion between dark energy and gravitational ponderable matter at the crucial age $T_+$ . A second mega quantum of action, also at the crucial age, comes into the play

At that crucial age the quantitative relation between Dark Energy (and mass) and the gravitational ponderable mass (and energy) was also crucial. What was the proportion between the Dark Energy and Gravitational Ponderable Matter at the crucial age? Let us examine this relation in the standard model of the Universe. At the crucial age  $T_+ = t_{\Lambda} = \frac{1}{c\Lambda^{1/2}}$  the so-called critical density of the Universe was

$$\rho_{crit+} = \frac{3H_+^2}{8\pi G} = \frac{3}{8\pi G t_+^2} = \frac{3}{8\pi G t_{\Lambda}^2}.$$

Then the a-dimensionless density parameters  $\Omega_{\Lambda+} = \rho_{\Lambda}/\rho_{crit+} = 0.3333\dots$  and  $\Omega_{G+} = \rho_G/\rho_{crit+} = 0.6666\dots$ . So, at the crucial age of the Universe there were 33% of Dark Energy and 66% of Gravitational Ponderable Matter. Nevertheless, the centrifugal pressure of Dark Energy overcame the gravitational attraction of the ponderable matter. Why? Gravitational interactions are interactions between masses of the ponderable matter. So we can assume that at the crucial age the half part of the ponderable matter interacted with the second part. We can divide the matter inside the causally bounded sphere doing symmetrical sections of the sphere into two hemispheres. Such hemispheres interact on the average at the distance equal to the radius of the sphere  $R_+ = l_{\Lambda}$ .

At the crucial age the Kittel's gravitational action that came then fully into play is given by  $H_{G+} = \frac{Gm_{G+}^2}{c}$  where  $m_{G+}$  is the half part of  $M_{G+} = 2 m_{G+}$ . Simple mathematical transformations and calculations show that  $H_{G+} = \frac{H_{\Lambda}}{8\pi} = \frac{1}{8\pi c\kappa\Lambda}$  and, after applying the Newtonian approximation, the  $F_{G+} = \frac{F_{\Lambda}}{8\pi} = \frac{1}{8\pi}$ . So, at the crucial age two Mega Quanta of Action entered in the game  $H_{\Lambda}$  and

$$H_G = \frac{1}{8\pi c\kappa\Lambda} \sim 5.29 \cdot 10^{84} J \cdot s \sim 3.32 \cdot 10^{94} GeV \cdot s \quad (24)$$

We see that gravitational interactions began to be then  $8\pi$  times weaker than the  $\Lambda$ - pressure allowing the second inflation to develop. Note that the quantity of DE increases when the radius  $R$  of the causally bounded sphere increases. The radius is raised to the third power according to the equation  $E_{\Lambda 0} = \rho_{\Lambda} c^2 R_0^3$ .

### 9. The coupling constant $1/8\pi = 0,039789909$ between anti-gravitation and gravitation

In section 2.b we spoke about two constants: the Newtonian gravitational constant  $G = 6.67408 \times 10^{-11}$  and the lambda anti gravitational constant  $G_A = \kappa c^4 = 1.677329786 \cdot 10^{-9}$ . They are connected with the coefficient  $1/8\pi$  that I propose to call coupling constant between gravitation and anti - gravitation because it connects all other quantities of the gravitational / anti-gravitational interactions. Not only  $G = G_A / 8\pi$  but also other quantities are connected in such a way, as we will see in the following sections.

### 10. Relations between lambda units and other sets of Units determined by universal constants

The sets of Units determined by universal constant are interrelated, interdependent, interconnected and therefore they can be expressed interchangeably. Let's begin with the mass density that is considered as very important in cosmology. The Planck mass density  $\varrho_P = \frac{c^5}{\hbar G^2}$  can be expressed using  $c$ ,  $\kappa$  and  $\Lambda$  as follows

$$\varrho_P = \frac{c^5}{\hbar G^2} = \frac{(8\pi)^2 H_\Lambda \Lambda}{\hbar \kappa c^2} = 5.155 \cdot 10^{96} \text{ kg/m}^3 \quad (25)$$

Since  $\varrho_\Lambda = \frac{\Lambda c^2}{8\pi G} = \frac{\Lambda}{\kappa c^2}$  we can also express the relation between  $\varrho_P$  and  $\varrho_\Lambda$  as follows

$$\varrho_P = \frac{(8\pi)^2 H_\Lambda \Lambda}{\hbar \kappa c^2} = \frac{(8\pi)^2 H_\Lambda}{\hbar} \varrho_\Lambda \quad (26)$$

When we transform (26) and take into account the two constants  $G$  and  $G_A$  then we obtain

$$\varrho_P \hbar G = 8\pi \varrho_\Lambda H_\Lambda G_A = 3,65 \cdot 10^{52} \text{ W} \quad (27)$$

In (27)  $\varrho_P \hbar G$  is the Planck's limitary power  $P_P = c^5/G$  and  $\varrho_\Lambda H_\Lambda G_A$  is  $\Lambda$ - power  $P_\Lambda = c/\kappa$ . Note that  $\Lambda$ - power is  $8\pi$  times weaker than Planck's one. In my opinion the components of (27) are not only esthetically beauty but indicate very well, before all, the physical dependence of power upon the mass density (containing energy)  $\varrho_P$  or  $\varrho_\Lambda$ , and upon the parameters of quantization  $\hbar$  or  $H_\Lambda$  and also upon the gravitational constant  $G$  or anti-gravitational constant  $G_A$

Let's show now the basic Planck's Units expressed by the constants  $c$ ,  $\kappa$  and  $\Lambda$  and their relation with the basic  $\Lambda$  - Units.

$$\begin{aligned} l_P &= (\hbar G/c^3)^{1/2} = (\hbar / 8\pi H_\Lambda \Lambda)^{1/2} = l_\Lambda (\hbar / 8\pi H_\Lambda)^{1/2} \\ t_P &= (\hbar G/c^5)^{1/2} = (\hbar / 8\pi H_\Lambda \Lambda c^2)^{1/2} = t_\Lambda (\hbar / 8\pi H_\Lambda)^{1/2} \\ m_P &= (\hbar c/G)^{1/2} = (1/c^2)(8\pi H_\Lambda \hbar \Lambda c^2)^{1/2} = m_\Lambda (8\pi \hbar / H_\Lambda c^4)^{1/2} \\ E_P &= (\hbar c^5/G)^{1/2} = (8\pi H_\Lambda \hbar \Lambda c^2)^{1/2} = E_\Lambda (8\pi \hbar / H_\Lambda)^{1/2} \end{aligned}$$

Note that in Nature there is a limitary maximal increase of momentum per time unit [16] and maximal limitary power [17].

$$\begin{aligned} F_{lim} &= (c^4/G) = (8\pi H_\Lambda \Lambda c) = 1,2107 \cdot 10^{44} \text{ N} \\ P_{lim} &= (c^5/G) = (8\pi H_\Lambda \Lambda c^2) = 3,63 \cdot 10^{52} \text{ W} \end{aligned}$$

Therefore, there is impossible to construct an accelerator in which the increase of momentum per time unit and the liberation of energy per time unit could be greater than  $(c^4/G)$  and  $(c^5/G)$  [6].

### 11. Let's consider an interesting analogy with de Broglie relativistic wave mechanics

Note that the proposed toy-model fits with de Broglie relativistic wave mechanics that was introduced at the historical beginning of QM. Louis de Broglie started with the assumption that  $h\nu = mc^2$ .

Let's follow him using the  $\Lambda$ -quantities that came into play at the crucial age  $H_\Lambda v_{\Lambda+} = M_{\Lambda+} c^2 = E_{\Lambda+}$  where  $v_{\Lambda+} = c\Lambda^{1/2} = 2.54 \cdot 10^{-18} s^{-1}$  is the lambda frequency at the crucial moment when the Universe was 9.66 billion years old and when its crucial lambda mass was  $M_{\Lambda+} \sim 4.89 \cdot 10^{51} \text{ kg}$ .

The lambda crucial "wavelength" was then equal to lambda length  $\lambda_{\Lambda+} = H_\Lambda / M_{\Lambda+} \cdot c = l_\Lambda \sim 9.66$  billion light years and the lambda wave or fluctuation period was equal then to the crucial lambda time  $T_{\Lambda+} = H_\Lambda / E_{\Lambda+} = t_\Lambda \sim 9.66$  billion years.

But are we really dealing with mega fluctuations, with "mega waves" in the mega scale? It sounds unrealistic and seems to be mere phantasy. but have we really to exclude them? Have we to exclude mega waves or fluctuations (e.g. of GPM densities) in our universe? Let's admit them at least in our game, i.e. in the toy-model.

## 12. Let's consider in addition a toy - Mega Heisenberg uncertainty relations

Since in each visible sphere the distribution of the GPM (i.e. Dark Matter /26,8% today/ and Ordinary Matter /4.9% today/) is very random and lambda stands in relation with the metric tensor  $\Lambda g$ , with its components  $(g_{\mu\nu})$  therefore we can try to introduce Mega Heisenberg uncertainty relations concerning DE  $\Delta E_{\Lambda H} \Delta t_H \geq H_\Lambda \Delta p_{\Lambda H} \Delta l_H \geq H_\Lambda$ . Where  $E_{\Lambda H}$  is DE at Hubble changing time i.e. at  $t_H$  that is just Hubble changing time and  $l_H$  is the time-dependent Hubble length, Hubble radius.

That is only my suggestion in the proposed toy-model. However, when in the toy-model we take seriously the Mega Uncertainty Relations then we must be aware that at the crucial age  $T_+$  the  $\Lambda$ -Mega Quanta of DE, sent in all directions from the toy-observer, were the greatest and they will decrease when the age  $T_H$  of universe increases. The lowest will come in the play when the percentage of DE will approach to 100%.

Perhaps the unification of the Relativistic Cosmology with QM has to be done in the large scale in the mega domain and not in the small scale one. However, the Mega Heisenberg relations can seem to be unrealistic. I consider the proposal of Mega Heisenberg relations only as a primitive toy-design that perhaps will inspire some future investigations.

In the observed spheres in our Universe the observers are dealing with a mixture of GPM and the anti-gravitational DE. The vacuum is deformed by islands of GPM e.g. by clusters of galaxies. We are dealing with an entanglement of GPM deforming, curving the vacuum and straightening up the DE.

Gravitational and lambda interactions are entirely negligible and insignificant in the micro world of the elementary particles. But they are very significant in the mega scale among celestial bodies, galaxies and especially among the clusters of galaxies and therefore  $H_\Lambda$  can play its part only in Mega Scale not in micro scale. Therefore e.g. we have discovered gravitational waves when two great black holes collide.

## 13. Will we deal with a new mathematical singularity when our Universe is about 16.68 billion years old? Will a second crucial event $T_{++}$ happen then?

As was indicated in the section 6 of this paper the expansion of the Universe began to accelerate when our Universe was roughly about 9.66 billion years old. So, the era of DE domination began roughly about 4.16 billion years ago. At that crucial date the percentage of DE was 33% and of GPM 66%. Henceforth the percentage of DE has increased much. As already mentioned after PLANK mission the more precise data indicate that we have now about 68-69% of DE and 31-32% of GPM [9].

The second crucial date  $T_{++}$  will take place when, because of the same DE activity, its increasing percentage will approach to 100% and the percentage of GPM will decrease to 0% (showing that its average density will become extremely diluted). Note that, if the DE percentage could become 100% then the so-called time-dependent critical density  $\rho_{crit}$  of the Universe would be equal to the DE mass density:  $\rho_{crit} = \rho_\Lambda = \frac{3H_{++}^2}{8\pi G} = \frac{3}{8\pi G T_{++}^2} = \frac{\Lambda c^2}{8\pi G}$ . (Where  $H_{++}$  means the time-dependent Hubble parameter at that date). Let's do the simple calculation  $\frac{3}{8\pi G T_{++}^2} = \frac{\Lambda c^2}{8\pi G}$ ;  $T_{++}^2 = 3/\Lambda c^2$ .

Since  $1/\Lambda c^2 = t_\Lambda^2$  hence  $T_{++}^2 = 3 t_\Lambda^2$

Since  $t_{\Lambda} \sim 9.66$  billion years hence  $T_{++} = 3^{1/2} \cdot 9.66 \sim 16.73$  billion years.

So, equation taken from the mathematical structure of the Standard Model disposes us to indicate the date  $T_{++} = 1/H_{++} \sim 16.73$  billion years of a strange event (100% of DE and 0% of GPM). So, the strange event could happen roughly about 16.73 billion years after the Big Bang i.e. about 2.91 billion years from now). The mathematically shown state (100% of DE and 0% of GPM) seems to be a future mathematical singularity and not a real physical state that will really happen because 100% of DE and 0% of GPM appears as a physical nonsense. The date 16.73 billion years after the Big Bang will probably happen but the GPM though extremely diluted will not be totally destroyed and the DE will therefore not arrive to 100%. But what will really happen then? Will we deal with a Mega Quantum Jump from the Old Universe time before  $T_{++}$  to the New Universe time after it by means, perhaps, of a “Mega Quantum Tunneling of the whole Universe” to avoid the increasing of DE percentage. Will then the DE percentage begin to increase from 0% after the time  $T_{++}$  because its percentage cannot exceed the 100%. Or will begin an era of an open Universe with the curvature parameter  $k = -1$  in which the percentage of DE will approach to 100% and GPM to 0% in an infinitely long time (an eternal inflation). Let's add that also at the strange date 16.73 billion years the Cosmic Microwave Background (CMB) that now has the average temperature 2.7 K will probably approach to 0 K though DM transforms partially into CMB. So, when we go backwards in the time about 13.819 billion years ago we collide with the past mathematical singularity and with a very hot universe having about Planck temperature of the electromagnetic *PM*. And if we go forwards in time roughly about 2.91 billion years from now, from the present moment, we collide with a future mathematical singularity and a very cold universe about 0 K. How overcome theoretically the future singularity?

Let's ask questions:

- (1) Will we deal with a quantum tunnel? With a new cycle that will begin with a Big Bang like explosion or a new era of an open Universe will begin an eternal inflation? If the first case will happen, will the extremely dominated at the critical moment DE (that is rest massless) like the rest massless Higgs – field, emit at that strange moment, Higgs bosons and a new cycle of the Universe will begin?
- (2) A Big Recycling? What will happen with the GPM in the first considered case? Will it be destroyed because of a new high temperature or will it remain as relicts of the previous cycle and will be seen at the horizon as quasars by the observers of the next cycle? What will happen with the CMB? Will it after the strange date  $T_{++}$  become again very hot with Planck's temperature? I am asking these questions because I myself I am not able to answer them. The Standard Model, in my opinion, is a magnificent theoretical tool that works very well. It seems to me that it predicts also very well the two indicated above crucial events. I think we will deal with a new cycle that will last the next 16.73 billion years and so on. I do not believe in an eternal second inflation with a Big Rip and a Big Freeze. I prefer the belief in a new cycle, in a Big Recycling with perhaps a kind of a quantum phase transition, mega quantum jump with a density of matter transition.

#### 14. Final remark

Roger Penrose in his book *Fashion, Faith and Fantasy in the New Physics of the Universe* [18] tries to show how many fashion, faith and human fantasy there is in the New Physics of the Universe. Perhaps the introduced, in this paper, toy-model belongs to models created only by my human fantasy.

#### References

- [1] Stoney G J 1874 On the Physical Units of Nature *Notes and Records of the Royal Society*. **29**, Plate 14
- [2] Stoney G J 1881 *Phil. Mag* **5** 11 381-91
- [3] Planck M 1899 *Sitzungsberichte d. Preus. Akad. Wiss.* 5 Mitteilung, 440,
- [4] Kittel C et al 1965 *Mechanics, Berkeley Physics Course I* McGraw-Hill N Y p 302
- [5] Weinberg S 1972 *Gravitation and Cosmology* J Wiley and Sons New York 207-8
- [6] Kostro L 2010 The physical meaning of the coefficients  $c^n/G$ , ( $n = 0, 1, \dots, 5$ ) and the standard

- model of the universe *Search for Fundamental Theory* eds. R Amoroso R Rowlands P and S Jeffers AIP Proceedings 1316 Melville New York 165-79
- [7] Kostro L 2016 Are there mega quanta of action playing part in Hubble spheres? *Unified Field Mechanics* eds. R L Amoroso L H Kaufman and P Rowlands World Scientific 518-21
  - [8] Kostro L 2018  $\Lambda$ - Units and  $\Lambda$ - quantum of action have they any physical sense? *Unified Field Mechanics II: Formulations and Empirical Tests* eds R L Amoroso L H Kauffman P Rowlands and G Albertini World Scientific 481-7
  - [9] Bouchet F R et al Planck 2013 results, XVI cosmological parameters. *Astronomy & Astrophysics manuscript* p 1011
  - [10] Kostro L 2000 *Einstein and the Ether* Apeiron, Montreal
  - [11] Kostro L 1993 The evolution of Einstein's ideas concerning ether space and time *History of Physics in Europe in the 19<sup>th</sup> and 20<sup>th</sup> Centuries* ed. F Bevilaqua Editrice Compositori Bologna 177-183
  - [12] Einstein A Letter to H A Lorentz 17.06.1916 *EA* 16-453
  - [13] Einstein A 1934 Das raum-äther-und feld-problem der physik *Mein Weltbild Querido* Verlag Amsterdam 229-248
  - [14] Einstein A and Infeld L 1947 *The Evolution of Physics* University Press, Cambridge
  - [15] Einstein A 1949 Relativity and the ether, Leiden speech; Einstein A 1920 *Essays in Physics* Philosophical Library New York 98-111
  - [16] Kostro L 1999 *Physics Essays* **12** 1 182-189
  - [17] Kostro L 2000 *Physics Essays* **13** 1 143-149
  - [18] Penrose R 2016 *Fashion, Faith and Fantasy in the New Physics of the Universe* Princeton University Press