Maimonides` discrete time-Caldirola *chronon* in cosmology

Miroslaw Kozlowski

Emeritus ,Physics Department Warsaw University , Warsaw, Poland

Abstract

In this paper we present the anthropic type description of the history of the Universe. The evolution of the the radius Universe, velocity of expansion and acceleration are calculated. In addition the cosmological parameter Λ in de Sitter Universe is calculated. The agreement with the existing observational data is good. The future of the Universe is diagnosed and discussed

Time is composed of time-atoms, i.e. of many parts, which on account of their short duration cannot be divided

The Guide for perplexed

Majmonides, 1190, transl. M. Friedlander, 1904) p. 121 George Routledge, London.

1 Introduction.

It is well known that idea of discrete structure of time can be applied to the ``flow" of time. The idea that time has ``atomic" structure or is not infinitely divisible, has only recently come to the fore as a daring and sophisticated hypothetical concomitant of recent investigations in the physics elementary particles and astrophysics. Yet in the Middle Ages the atomicity of time was maintained by various thinkers, notably by Maimonides [1]. In the most celebrated of his works: *The Guide for perplexed* he wrote: *Time is composed of time-atoms, i.e. of many parts, which on account of their short duration cannot be divided*

In the recent years the growing interest for the source of Universe expansion is observed. After the work of Supernova detecting groups the consensus for the acceleration of the moving of the space time is established [2, 3]. In this paper we will developed the diffusion model for the expansion of the Universe

We will study the influence of the repulsive gravity ($G < 0$) on the temperature field in the universe and cosmological constant Λ. To that aim we will apply the quantum hyperbolic heat transfer equation (QHT) formulated in our earlier papers [4, 5].

When substitution $G \to -G$ is performed in QHT the Schrödinger type equation is obtained for the temperature field. In papers [4, 5] the quantum heat transport equation (diffusion equation) in a Planck Era was formulated:

$$\tau \frac{\partial^2 T}{\partial t^2} + \frac{\partial T}{\partial t} = \frac{\hbar}{M_p} \nabla^2 T. \tag{1}$$

In equation (1) $\tau = \left(\frac{\hbar G}{c^5}\right)^{1/2}$ is the relaxation time, $M_p = \left(\frac{\hbar G}{c}\right)^{1/2}$ is the mass of the Planck particle, $\hbar$, c are the Planck constant and light velocity respectively and G is the gravitational constant. The crucial role played by gravity (represented by G in formula (28)) in a Planck Era was investigated in paper [5]. For a long time the question whether, or not the fundamental constant of nature G varies with time has been a question of considerable interest. Since P. A. M. Dirac [6] suggested that the gravitational force may be weakening with the expansion of the Universe, a variable G is expected in theories such as the Brans-Dicke scalar-tensor theory and its extension [7, 8]. Recently the problem of the varying G received renewed attention in the context of extended inflation cosmology [9]. It is now known, that the spin of a field (electromagnetic, gravity) is related to the nature of the force: fields with odd-integer spins can produce both attractive and repulsive forces; those with even-integer spins such as scalar and tensor fields produce a purely attractive force. Maxwell's electrodynamics, for instance can be described as a spin one field. The force from this field is attractive between oppositely charged particles and repulsive between similarly charged particles.

The integer spin particles in gravity theory are like the graviton, mediators of forces and would generate the new effects. Both the graviscalar and the graviphoton are expected to have the rest mass and so their range will be finite rather than infinite. Moreover, the graviscalar will produce only attraction, whereas the graviphoton effect will depend on whether the interacting particles are alike or different. Between matter and matter (or antimatter and antimatter) the graviphoton will produce repulsion. The existence of repulsive gravity forces can to some extent explains the early expansion of the Universe [6].

2. The model

In this paper we will describe the influence of the repulsion gravity on the quantum thermal processes in the universe. To that aim we put in equation (28) $G \to -G$. In that case the new equation is obtained, viz.

$$i\hbar \frac{\partial T}{\partial t} = \left(\frac{\hbar^3 |G|}{c^5}\right)^{1/2} \frac{\partial^2 T}{\partial t^2} - \left(\frac{\hbar^3 |G|}{c}\right)^{1/2} \nabla^2 T. \tag{2}$$

For the investigation of the structure of equation (2) we put:

$$\frac{\hbar^2}{2m} = \left(\frac{\hbar^3 |G|}{c}\right)^{1/2} \tag{3}$$

and obtains

$$m = \frac{1}{2} M_p$$

with new form of the equation (2)

$$i\hbar \frac{\partial T}{\partial t} = \left(\frac{\hbar^3 |G|}{c^5} \right)^{1/2} \frac{\partial^2 T}{\partial t^2} - \frac{\hbar^2}{2m} \nabla^2 T. \tag{3}$$

Equation (3) is the quantum Heaviside equation discussed in paper [5]. To clarify the physical nature of the solution of equation (3) we will discuss the diffusion approximation, i.e. we omit the second time derivative in equation (3) and obtain

$$i\hbar \frac{\partial T}{\partial t} = -\frac{\hbar^2}{2m} \nabla^2 T. \tag{4}$$

Equation (4) is the Schrödinger type equation for the temperature field in a universes with $G < 0$.

Both equation (4) and diffusion equation:

$$\frac{\partial T}{\partial t} = \frac{\hbar^2}{2m} \nabla^2 T \tag{5}$$

are parabolic and require the same boundary and initial conditions in order to be "well posed".

The diffusion equation (4) has the propagator [10]:

$$T_D\left(\vec{R}, \Theta\right) = \frac{1}{\left(4\pi D \Theta\right)^{3/2}} \exp\left[-\frac{R^2}{2\pi\hbar\Theta} \right], \tag{6}$$

where

$$\vec{R} = \vec{r} - \vec{r}\,', \quad \Theta = t - t'.$$

For equation (4) the propagator is:

$$T_S\left(\vec{R}, \Theta\right) = \left(\frac{M_p}{2\pi\hbar\Theta} \right)^{3/2} \exp\left[-\frac{3\pi i}{4} \right] \exp\left[\frac{i M_p R^2}{2\pi\hbar\Theta} \right] \tag{7}$$

with initial condition $T_S(R, 0) = \delta(R)$

3.The anthropic argument

In equation (7) $T_S((R), \Theta)$ is the complex function of R and Θ. For anthropic observers only the real part of T is detectable, so in our description of universe we put:

$$\operatorname{Im} T\left(\vec{R}, \Theta\right) = 0. \qquad (8)$$

The condition (8) can be written as (bearing in mind formula (7):

$$\sin\left[-\frac{3\pi}{4} + \left(\frac{R}{L_p}\right)^2 \frac{1}{4\tilde{\Theta}}\right] = 0, \qquad (9)$$

where $L_P = \tau_P c$ and $\tilde{\Theta} = \Theta / \tau_p$. Formula (9) describes the discretization of R

$$R_N = \left[\left(4N\pi + 3\pi\right) L_p\right]^{1/2} \left(tc\right)^{1/2}, \quad N = 0, 1, 2, 3... \qquad (10)$$

In fact from formula (38) the Hubble law can be derived

$$\frac{\dot{R}_N}{R_N} = H = \frac{1}{2\tau}, \qquad (11)$$

independent of N.

In the subsequent we will consider R (10), as the space-time radius of the N − universe with "atomic unit" of space L_P.

It is well known that idea of discrete structure of time can be applied to the "flow" of time. The idea that time has "atomic" structure or is not infinitely divisible, has only recently come to the fore as a daring and sophisticated hypothetical concomitant of recent investigations in the physics elementary particles and astrophysics. Descartes [11]. The shortest unit of time, atom of time is named *chronon* [12]. Modern speculations concerning the *chronon* have often be related to the idea of the smallest natural length is L_P. If this is divided by velocity of light it gives the Planck time $\tau_P = 10^{-43}$ s, i.e. the *chronon* is equal τ_P. In that case the time t can be defined as

$$t = M\,\tau_p, \quad M = 0, 1, 2, \ldots \qquad (12)$$

Considering formulae (9) and (12) the space-time radius can be written as

$$R(M, N) = \pi^{1/2} M^{1/2} \left(N + \frac{3}{4}\right)^{1/2} L_p, \quad M, N = 0, 1, 2, 3, ... \qquad (13)$$

Formula (13) describes the discrete structure of space-time. As the $R(M, N)$ is time dependent, we can calculate the velocity, $\upsilon = dR/dt$, i.e. the velocity of the expansion of space-time

$$\upsilon = \left(\frac{\pi}{4}\right)^{1/2} \left(\frac{N+\frac{3}{4}}{M}\right)^{1/2} c, \tag{14}$$

where *c* is the light velocity. We define the acceleration of the expansion of the space-time

$$a = \frac{d\upsilon}{dt} = -\frac{1}{2}\left(\frac{\pi}{4}\right)^{1/2} \left(\frac{N+\frac{3}{4}}{M^3}\right)^{1/2} \frac{c}{\tau_p}. \tag{15}$$

Considering formula (15) it is quite natural to define Planck acceleration:

$$A_p = \frac{c}{\tau_p} = \left(\frac{c^7}{\hbar G}\right)^{1/2} = 10^{51}\,\mathrm{ms}^{-2} \tag{16}$$

and formula (43) can be written as

$$a = -\frac{1}{2}\left(\frac{\pi}{4}\right)^{1/2} \left(\frac{N+\frac{3}{4}}{M^3}\right)^{1/2} \left(\frac{c^7}{\hbar G}\right)^{1/2}. \tag{17}$$

In Table I the numerical values for *R*, υ and *a* are presented. It is quite interesting that for *N*, $M \to \infty$ the expansion velocity $\upsilon < c$ in complete accord with relativistic description. Moreover for *N*, $M >> 1$ the υ is relatively constant $\upsilon = 0.88\, c$. From formulae (38) and (42) the Hubble parameter *H*, and the age of our Universe can be calculated

$$\upsilon = HR, \qquad H = \frac{1}{2M\tau_p} = 5\cdot 10^{-18}\ \mathrm{s}^{-1},$$
$$T = 2M\tau_p = 2\cdot 10^{17}\ \mathrm{s} \sim 10^{10}\ \text{years}, \tag{18}$$

which is in quite good agreement with recent measurement [13, 14, 15].

As is well known in de Sitter universe the cosmological constant Λ is the function of *R*, radius of the Universe,

$$\Lambda = \frac{3}{R^2}. \tag{19}$$

Substituting formula (38) to formula (47) we obtain

$$\Lambda = \frac{3}{\pi N^2 L_p^2}, \quad N = 0, 1, 2.... \tag{20}$$

The result of the calculation of the radius of the Universe, *R*, the acceleration of the spacetime, *a*, and the cosmological constant, Λ are presented in Figs. 1, 2, 3, 4 for different values of number *N*. As can be easily seen the values of *a* and *R* are in very good agreement with observational data for present Epoch. As far as it is concerned cosmological constant Λ for the firs time we obtain, the history of cosmological constant from the Beginning to the present Epoch.

3. Conclusions

In this paper the diffusion model of the Universe expansion is developed. Considering the anthropic argument Universe temperature :$ImT(\mathbf{r},t) =0$ the quantization of the space- time is obtained. The radius, velocity of the Universe expansion, the acceleration and cosmological parameter as the function of the discreteness parameter N is obtained. For $N=10^{60}$ the age Universe= 10^{17} s = the present Epoch. The present day Universe is the relic of the primordial point Universe which expands in discrete steps N, M=1,2 ,…. 10^{60}….

Figure captions

Fig.1,a,b,c The calulated values of the Spacetime radius (a) , Acceleration (b) anf Cosmological constant (c) for times 0 to 10^5 Planck times

Fig.2,a,b,c The calulated values of the Spacetime radius (a) , Acceleration (b) anf Cosmological constant (c) for times 0 to 10^{20} Planck times

Fig.3,a,b,c The calulated values of the Spacetime radius (a) , Acceleration (b) anf Cosmological constant (c) for times 0 to 10^{60} Planck times

Fig.4,a,b,c The calulated values of the Spacetime radius (a) , Acceleration (b) anf Cosmological constant (c) for times 0 to 10^{100} Planck times

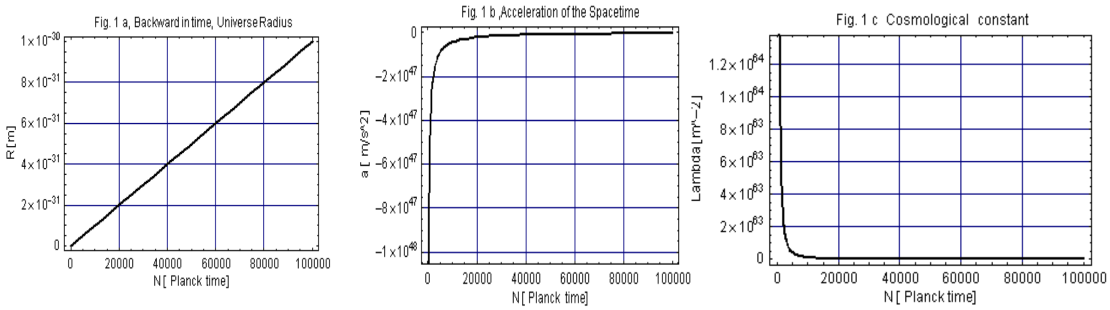
Fig. 1 a, Backward in time, Universe Radius
R [m]
N [Planck time]
Fig. 1 b ,Acceleration of the Spacetime
a [m/s^2]
N [Planck time]
Fig. 1 c Cosmological constant
Lambda [m^-2]
N [Planck time]

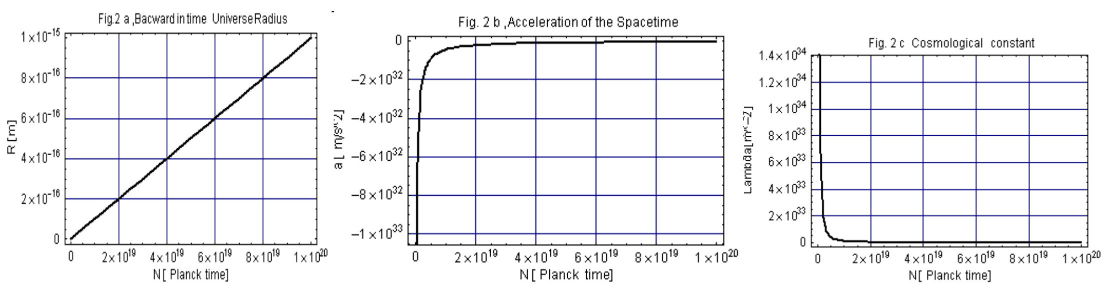
Fig.2 a ,Bacward in time Universe Radius
R [m]
N [Planck time]
Fig. 2 b ,Acceleration of the Spacetime
a [m/s^2]
N [Planck time]
Fig. 2 c Cosmological constant
Lambda [m^-2]
N [Planck time]

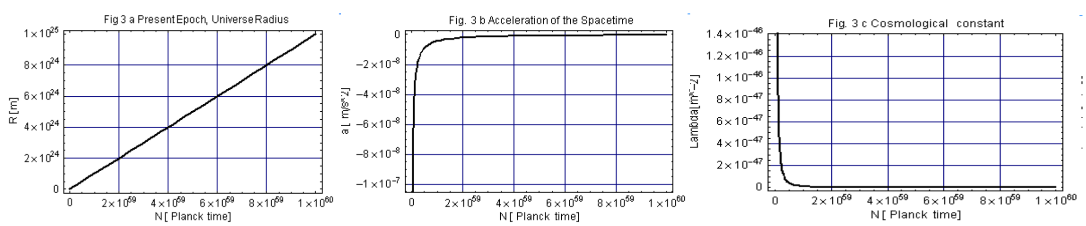
Fig 3 a Present Epoch, Universe Radius
R [m]
N [Planck time]
Fig. 3 b Acceleration of the Spacetime
a [m/s^2]
N [Planck time]
Fig. 3 c Cosmological constant
Lambda [m^-2]
N [Planck time]

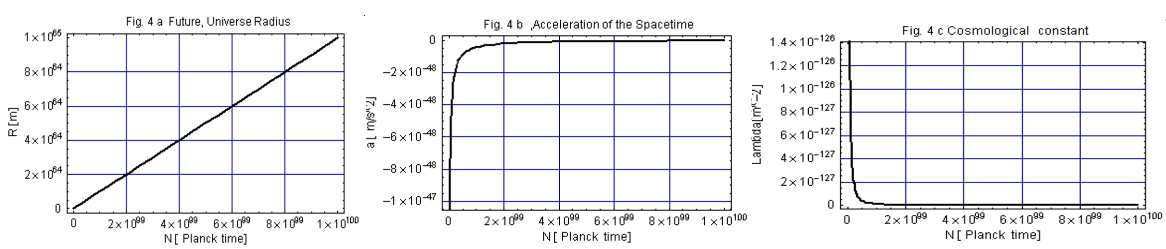
Fig. 4 a Future, Universe Radius
R [m]
N [Planck time]
Fig. 4 b ,Acceleration of the Spacetime
a [m/s^2]
N [Planck time]
Fig. 4 c Cosmological constant
Lambda [m^-2]
N [Planck time]

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