THREE LEVELS OF UNDERSTANDING THE UNIVERSE

Miroslav Súkeník, Jozef Šima
Slovak University of Technology, FCHPT, Radlinského 9, 812 37 Bratislava, Slovakia
sukenik@nextra.sk; jozef.sima@stuba.sk

Abstract
In the paper, a description of the Universe is provided at three different levels. The lowest one represents an elementary description by means of Friedmann equations. A higher level is a quantum mechanical description involving wave equation and the Universe wave function. The highest level is a mathematical description leading to the conclusion that the Universe is infinite both in time and space, it has never been created and never will cease. Based on a causal coupling of the past and future, an independent derivation of the Feigenbaum constant δ is possible.

1: INTRODUCTION

At the time being, we act as witnesses of unbelievable progress in science and technology. In spite of indisputable achievements having been reached by cosmology, in spite of unbelievable improvements in observation technology within the last decades, our image of the Universe has become notably complicated. Open questions can be exemplified by the following issues. The nature of dark matter and dark energy is still far from comprehensively apprehended. We do not know the cause, mechanism and initial conditions of the Universe creation. It is not clear whether there was an inflation phase of the Universe expansion. We are not able to prove the possible existence of extradimensions. We do not understand the latest measurements of enormous matter aggregation and bubbles of empty space disturbing our ideas on a high homogeneity of our Universe. The quantum cosmology and quantum theory applied to the Universe is beyond our comprehension. We do not know primary conditions leading to the formation of galaxies, clusters and superclusters. It seems to be strange that we are living in a so improbable era, when the consequences of the Universe expansion deceleration in the past are exactly compensated by its present acceleration.
It is a mystery, that the value of specific entropy (*i.e*. the ratio of relict photons and baryons) is 10 times lower than its theoretically calculated value. We can only hypothesed what is beyond the horison and whether the physical laws are identical there as those in our Universe. Are we part of Multiverse, is there „country“ of all possible universes?
It seems, that a chaos has become dominate in cosmology. New cosmological models are emerging as on a running belt and situation has become still less transparent. Some of the above mentioned questions might be answered using the Expansive Nondecelerative Universe (ENU) model [1 – 6]. This paper is focused in three levels of understanding of the Universe applying the ENU model.

2: ELEMENTARY DESCRIPTION

Our model of the Universe expansion (Expansive Nondecelerative Universe, hereinafter ENU) and its consequences are based on a simple premise, that the rate of the Universe expansion is constant and equal to the speed of light. Moreover, the Universe mean energy density is identical to its critical energy density.

There are three limiting conditions characterizing the ENU model, namely

$$\Lambda = 0 \tag{1}$$

where Λ is the cosmological constant,

$$k = 0 \tag{2}$$

where k is the curvature, and

$$a = c \cdot t_U \tag{3}$$

where a is the scale factor, c is the speed of light in vacuum, t_U is the cosmological time (their present ENU-based values are following: $a = 1.229 \times 10^{26}$ m; $t_U = 1.373 \times 10^{10}$ yr).
Within the classic models of the Universe, the flat Universe is required to gradually decelerate its expansion. It is a case where the gravitational force affects the Universe globally. Contrary, in the ENU, the gravity affects it only locally.
The dynamic nature of the ENU is described by Friedman equations. Introducing a dimensionless conform time the equations can be expressed as follows :

$$\frac{d}{d\eta}\left(\frac{1}{a}.\frac{da}{d\eta}\right) = -\frac{4\pi G}{3c^4}a^2(\varepsilon + 3p) \tag{4}$$

$$\left(\frac{1}{a}.\frac{da}{d\eta}\right)^2 = \frac{8\pi G}{3c^4}a^2\varepsilon - k \tag{5}$$

where ε is the energy density, p is the pressure and the scale factor a is expressed as

$$a = \frac{da}{d\eta} \tag{6}$$

Introducing the conditions (1) to (3) into relations (4) and (5), we get

$$\varepsilon = \frac{3c^4}{8\pi G a^2} \tag{7}$$

$$p = -\frac{\varepsilon}{3} \tag{8}$$

The energy density can be expressed also in the form

$$\varepsilon = \frac{3m_U c^2}{4\pi a^3} \tag{9}$$

where m_U is the mass of the Universe ($m_U \cong 8.673x10^{52}$ kg).
Combining of (7) and (9) one obtains

$$a = \frac{2G m_U}{c^2} \tag{10}$$

It follows directly from (10) that a time evolution of the matter must occur. An amount of the mass created in one second is δ

$$\delta = \frac{dm_U}{dt} = \frac{m_U}{t_U} = \frac{c^3}{2G} \tag{11}$$

It means that an amount of the matter created in our Universe in a second is equal to about 10^5 Sun mass. (In the inflationary model, the same amount of matter is emerging from beyond the

horizon). It is not too much matter if the Universe dimensions are taken into accout. For the sake of illustration, it represents a proton in a cube of 1 km^3 within a year. There is no global scale gravity in the ENU, which could decelerate the Universe expansion.
The ENU model is this in compliance with a Hawking's statement, that the total mass-energy of our Universe must equal precisely to 0 [7]. It means, that the matter representing the positive component of the energy, is just compensated with the gravitational field, representing the negative component of the energy. The conservation laws are therefore obeyed.

3: QUANTUM-MECHANICAL LEVEL OF DESCRIPTION

At the quantum theory level it holds for the ENUmodel

$$\left(\frac{d^2}{da^2} + \omega^2 - \omega^4 a^2\right)\psi_U = 0 \tag{12}$$

This equation (12) is the Wheeler-De Witt wave equation of the Universe and ψ_U represents a Universe wave function

$$\psi_U = \exp\left(-\frac{a^2\omega^2}{2}\right) \tag{13}$$

where $\omega = \frac{1}{l_{PC}}$ and l_{PC} is the Planck lenght. This second level of the Universe understanding and description is substantially deeper and more complex.
Along with describing the Universe dynamics, equation (12) leads to the result, that the total energy of the Universe equals zero. To reach equivalency of the Universe wave function with the ground state of linear harmonic oscilator, it must be normalized.

$$\Psi_U = \frac{1}{(\pi)^{\frac{1}{4}}} e^{-\frac{a_x^2}{2}} \tag{14}$$

where $a_x = \frac{a}{l_{PC}}$
Our approach lies in the procedure integrating this wave function (for one distinct Universe) over the entire spacetime obeying the requirement, that the integral of the wave function square must equal to 1.

$$\int_{-\infty}^{\infty} \psi_U^2 da_x = 1 \tag{15}$$

This is the known Gauss integral. The right probability will thus be reached only if perform the integration from -∞ to +∞. It follows, that our Universe exists eternally and the Big Bang is meaningless. In a hypothetical case of the Big Bang (integration from 0 to ∞) it would hold

$$\Psi_U = \frac{(2)^{\frac{1}{2}}}{(\pi)^{\frac{1}{4}}} e^{-\frac{a_x^2}{2}} \tag{16}$$

and

$$\psi_U = \int_0^\infty \psi_U^2 da_x = 1 \tag{17}$$

Solution (16) does not correspond, however, to physical equivalent of the ground state of linear harmonic oscilator.

4: MATHEMATICAL LEVEL OF DESCRIPTION

The Universe development is illustrates in Figure 1. The axes *x* and *y* represent the cosmological time and the Universe dimensions, respectively. The beginning of the expansion lies in the point 0. Our current position is represented by the point P. The universe boundaries form a past causal horizon in the form of a light cone.
The Universe expansion will continue which is expressed by dashed lines. We show also a future causal horizon as a cone with its apex in the point M on the time axis. It can be understood as follows. At the time being, we are able to influence our nearest future. We may take a decision what to do tomorrow and fulfil the decision.
The further is the scheduled future, the less possibility is to affect it. If the current Universe is governed by a single wish, it can be planned and influenced only up to the point M, which is a maximum cosmological time $t_{\max}$ for us. There is no meaning to evaluate the future beyond this limit. At this moment we do not know the maximum cosmological time (the frontiers of the future causal horizon are shown only for ilustration in Fig. 1), we can, however, easily come to the result.

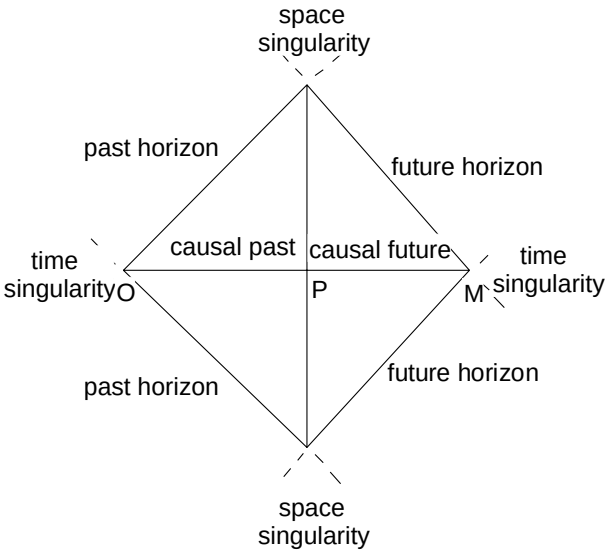

Fig. 1 *A chart of the Universe evolution*

The angle between the future causal horison and the axis *x* is β and the following relation must be hold.

$$\beta = \frac{a_{pr}}{ct_{\max}} \tag{18}$$

where a_{pr} is the present gauge factor of the Universe and $t_{\max}$ is the maximum time (point M). Based on the ENU postulates we provided the evidence that the lighest object gravitationally

affecting its surroundings is a particle with the Planck mass (~ 10^{-8} kg). If such a particle has an effect on the highest possible scale (a_{pr}), it represents a minimum impact in the Universe as a whole. This minimum effect is able to curve photons trajectory and focus them to a single point representing the future singularity, *i.e.* the end of time (maximum time from the viewpoint of causality). The angle of the curvature is, of course, β and its relativistic form is

$$\beta = \frac{l_{PC}}{a_{pres}} \tag{19}$$

Based on equations (18) and (19) the maximum value of time, 10^{71} years is obtained.
At the time being, we are just in the middle of this time axis (being in logarithmic scale). We suppose that due to a time change of some physical constants, this time value is valid for any observer both in the past and the future. It means that each observer will perceive himself/herself as being in the middle of time axis. All of these ideas may be unified and expressed in an elegant mathematical form.
Let us notice the following function :

$$y_{(x)} = \frac{\ln x}{x+1} \tag{20}$$

and its graphic expression (Fig. 2)

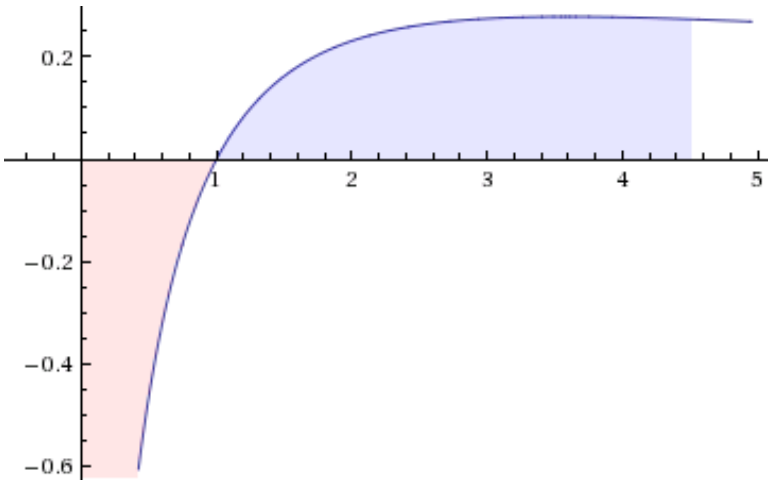

Fig. 2 *Dependence of real time (y-axis) on the our own time (x-axis).*

Our own time is on *x*-axis (expressed as dimensionless, in logarithmic way) and it appertains to all local Universes with their own horizon and this time running from 0 to ∞.
The axis *y* represents the real time running from −∞ and valid in the entire Multiverse. The curve of function *y*(x) in Fig. 2 crosses the *x*-axis in the point *x* = 1, which represents our present time. Our past time is in the left part from this point, the future in the right past. When our own past time is approaching 0 value, the real time is approaching −∞. It should be stressed that the real time and our own time are mutually perpendicular in the past. In the future, the real time will have positive value and in infinity it will approach the own time, the *x*-axis.
In the future, the real time and own time will become parallel and they can be identical. This is why it can be said, that the Universe is infinite in time and space. The own time can be perceived as a **projection of the real time to the *x*-axis.** It follows from Fig. 1, that the area of the causal past is identical to that of causal future (it should be noted that it is expressed in logarithic scale). The same must be valid also for the function *y*(*x*).

The area delimitated by this function and x-axis is negative for the past and positive for the future. There must, therefore, exist a limit a (analogous to the maximum time in Fig. 1), for which it is hold:

$$\int_0^a \frac{\ln x}{x+1} dx = 0 \tag{21}$$

Relation (21) is valid for $a \approx 4.503$. This is a very good accordance with the Feigenbaum constant $\delta = 4.6692$ [8, 9]. It cannot be otherwise. The number δ indicate the limiting values in which the causal past can influence the future. Further there is only a chaos.
It should be pointed out that is a new, independent, cosmology-based derivation of Feigenbaum constant.

5. CONCLUSION

It can be concluded that the mathematical description provides the deepest contribution to the understanding of the Universe. The considerations on the causality have lead us to a derivation of one of the fundamental constant δ, describing deterministic chaos with a sufficient accuracy. It is a universal constant valid in mathematics and physics. Equation (21) can thus be generalized as follows:

$$\int_0^\delta \frac{\ln t}{t+1} dt \cong 0 \tag{22}$$

The task can be seen from te other side. Given the preciselly known limit value δ, it can allow to derive more preciselly the function $y(x)$. It is connected to a high probability of the existence of real time, *i.e*. a Multiverse infinite both in time and space. The maximum of our function $y(x)$ lies in the point $x(\mathrm{m}) = 3.5911$. This is very close to a further important value of a governing parameter in the theory of deterministic chaos. At the value $x = 3.5699$, investigated system passes to chaotic mode, however, there are still regions of stability and periodicity. Reaching the value $\delta = 4.6692$ the system passes to definite chaos. The governing parameters x and δ are obtained either by repetitive tracing of behaviour of different physical systems, or by complicated iterations of relevant logistic equations. It is encouraging and surely not coincidental result, that both the values are very closely encoded in the properties of te function $y(x)$.
The governing parameter x in the range of (0 – 1) means that the system if fully stable. In our case it represents the past of the Universe which is, of course, unequivocal, stable and unaltered.

NOTE:
In Fig.1 the present time lies exactly in the centre point of x-axis. In Fig. 2 the situation is different, since in the future the own time will dilate with regard to the real time (an increment of the real time at y-axis will decrease). Feigenbaum limit in Fig. 2 will correspond, therefore, always to the maximum time in Fig. 1.

References

[1] Šima, J., Súkeník, M., Entropy 4 (2002) 152.
[2] Šima, J., Súkeník, M., Progress in Neutron Star Research, Wass, A.P., ed., Nova Science publishers, New York (2005) p.

[3] Šima, J. and Súkeník, M., (2011). „ Nondecelerative Cosmology: Background and Outcomes“. Pacific Journal of Science and Technology. 12(1):214-236
[4] Súkeník, M., Sima, J., Vixra: 1205.0046
[5] Súkeník, M., Sima, J., Vixra: 1208.0075
[6] Súkeník, M., Sima, J., Vixra: 1210.0047
[7] Hawking S., Mlodinov L. (2010): The Grand Design, Bantam Books, ISBN 0-553-80537-1
[8] Feigenbaum, M. (1983): "Universal Behavior in Nonlinear Systems". *Physica* 7D: 16–39. Bound as *Order in Chaos, Proceedings of the International Conference on Order and Chaos held at the Center for Nonlinear Studies, Los Alamos, New Mexico 87545,USA 24–28 May 1982*, Eds. David Campbell, Harvey Rose; North-Holland Amsterdam ISBN 0-444-86727-9.
[9] Briggs, K., (1991). "A precise calculation of the Feigenbaum constants". *Math. Comp.* 57 (195): 435–439. doi:10.1090/S0025-5718-1991-1079009-6