The Fine-Structure Constant as the Physical- Mathematical MILLENNIUM PROBLEM

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Abstract

This article solves the problem of variation of fundamental physical-mathematical constant (the *fine-structure constant*) in dependence of the age of the Universe. This problem has been named by as one of the MILLENNIUM PROBLEMS. The mathematical model of the evolution of the Universe (starting since the "*Bing Bang*") called Fibonacci special theory of relativity, underlies this study.

Key words: Einstein's special theory of relativity, Einstein's postulates, relativistic effects, Lorenz transformations, Fibonacci special theory of relativity, the main postulate of the Fibonacci special theory of relativity**,** Millennia Problems, fine-structure constant, Hyperbolic Fibonacci functions, the «golden" matrix, bifurcation points, material universe, dark and light ages, black hole,

Introduction

In 1900 the prominent mathematician David Hilbert presented *twenty-three Mathematical Problems* at the International Congress of Mathematicians in Paris [1] (see also [2],[3]).

Modern mathematicians decided to continue the great tradition of David Hilbert. In May 2000, by emulating to Hilbert, the *Clay Mathematics Institute of Cambridge* announced (in Paris, for full effect) the *seven "Millennium Prize Problems,"* each with a bounty of $1 million [4].

Modern physicists have decided not lag from mathematicians. They have formulated 10 *Physics Problems for the Next Millennium* [5]. These physical Millennium Problems have been presented at the *Strings* 2000 *Conference* (July, 10-15, University Michigan, Ann Arbor). All participants of the Conference were invited to formulate the ten most important unsolved problems in fundamental physics. Each participant was allowed to submit one candidate problem for consideration. To qualify, the problem must not only have been important but also well-defined and stated in a clear way.

The best 10 problems were selected at the end of the conference by a selection panel consisting of:

- Michael Duff (University of Michigan)
- David Gross (Institute for Theoretical Physics, Santa Barbara)
- Edward Witten (Caltech & Institute for Advanced Studies)

These physical problems are striking our imagination and therefore are called *Millennium Madness* [5].

The first physical MILLENNIUM PROBLEM, formulated by the prominent physicist, Nobel Prize Laureate in Physics-2004 David Gross (University of California, Santa Barbara), sounds as follows:

"*Are all the (measurable) dimensionless parameters that characterize the physical universe calculable in principle or are some merely determined by historical or quantum mechanical accident and ncalculable?"*

Let us analyze David Gross' formulation of the Physics MILLENNIUM PROBLEM:

1) First question is the following*: what are "(measurable) dimensionless parameters that characterize the physical universe"?*

2) The second question concerns the essence of this MILLENNIUM PROBLEM: are these "*dimensionless parameters … calculable in principle"* or are they *incalculable* (or

non calculable) and "*are some merely determined by historical or quantum mechanical accident?"*

By answering the first question, we immediately arrive at the main dimensionless constant, which is widely known in physics under the name of the *fine-structure constant* α.

As is highlighted in the Wikipedia article [6], *"in physics, the fine-structure constant, also known as Sommerfeld's constant, commonly denoted α (the Greek letter α), is a fundamental physical constant characterizing the strength of the electromagnetic interaction between elementary charged particles. It is related to the elementary charge (the electromagnetic coupling constant) e, which characterizes the strength of the coupling of an elementary charged particle with the electromagnetic field, by the formula* $4\pi\varepsilon_0\hbar c\alpha=e^2$*. Being a dimensionless quantity, it has the same numerical value in all systems of units. Arnold Sommerfeld introduced the fine-structure constant in 1916."*

Note that the physical significances of all symbols appearing in the formula $4\pi\varepsilon_0\hbar c\alpha=e^2$ are the following: ε_0 is *electric constant*; $\hbar$ is *Dirac's constant*; c =const $[\frac{m}{\sec}]$ is the speed of light in vacuum; e is *elementary charge* .

Thus, we can narrow down the problem, formulated by David Gross, as applied to the *fine-structure constant*, as following:

"Is the fine-structure constant, which characterizes the physical universe, calculable or non calculable?"

It should be noted that the essence of the MILLENNIIA PROBLEM, formulated by David Gross, in our definition does not changing. We just focus our attention on the main dimensionless constant of the physical world, the *fine-structure constant*.

From such modification of Gross's MILLENNIIA PROBLEM the following question arises: is *the problem of the fine-structure constant* a purely *physical* (*non calculable*) or *physical-mathematical* (*calculable*) problem?

In the present article, we attempt to consider the problem of the *fine-structure constant* as the *physical-mathematical problem*. This means that we consider fine-structure constant first of all as the physical problem. However, we are solving this problem by using mathematical method. To model this problem, we use a special mathematical theory, the so-called *Fibonacci special theory of relativity* [7]. The *Mathematics of Harmony* [8] and the *"golden" matrices* [9], introduced by Alexey Stakhov, underlie the *Fibonacci special theory of relativity.*

This article solves the problem of variation of the *fine-structure constant* in dependence of the age of the Universe, starting since the *Big Bang*. We have derived the formula for the *fine-structure constant*, which makes it possible to calculate the values of this constant for all stages of evolution of the Universe starting since the *Big Bang* (the *Dark Ages*, the *Light Ages* (the positive arrow of time) and the *Black Hole* (the negative arrow of time)).

Comparison of theoretical calculations and experimental astronomical observations shows a very high accuracy of coincidence of theoretical calculations and experimental data.

These results give the authors the right to argue that they obtained the original solution of the Physics MILLENNIA PROBLEM, formulated by David Gross, in terms of the fine-structure constant as the most important dimensionless constant of physical world.

1. Classical special theory of relativity

1.1. Lorentz transformations and classical special theory of relativity

The model of four-dimensional space-time, based on the transformation by Hendrik Antoon Lorentz, was used by Albert Einstein in 1905 [10] for the creation of the *special theory of relativity* (STR).

The mathematical apparatus for transformations of coordinates and time between different frames of reference (for the purpose of conservation of the electromagnetic field equations) has been formulated previously by the French mathematician Henri Poincare.

He offered to call them *Lorentz transformations,* although Lorenz has presented before only approximate formulas [11].

The main difference between Poincaré and Einstein's approaches, disguised as resemblance of their mathematical models, is the fact that both scientists interpreted differently the deep physical (and not only mathematical) nature of these models. All new effects, interpreted by Poincare as dynamic properties of ether, are interpreted in Einstein's theory of relativity as objective properties of space and time, they have been moved by Einstein from dynamics to kinematics. For more detailed about this, see the articles [7,11-18], and the articles *"The special theory of relativity"* and *"Poincare, Henri"* in Wikipedia, the free encyclopedia (https://ru.wikipedia.org)

This theory meant a revision of all concepts of classical physics. In today's presentation, the classical special theory of relativity (STR), is given by the system of two matrix transformations [7, 10-13]:

$$\begin{pmatrix} ct \\ x \\ y \\ z \end{pmatrix} = \begin{pmatrix} \frac{1}{\sqrt{1-(\bar{v})^2}} & \frac{\bar{v}}{\sqrt{1-(\bar{v})^2}} & 0 & 0 \\ \frac{\bar{v}}{\sqrt{1-(\bar{v})^2}} & \frac{1}{\sqrt{1-(\bar{v})^2}} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} ct' \\ x' \\ y' \\ z' \end{pmatrix}, \quad \begin{pmatrix} ct \\ x \\ y \\ z \end{pmatrix} = \begin{pmatrix} ch(\theta) & sh(\theta) & 0 & 0 \\ sh(\theta) & ch(\theta) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} ct' \\ x' \\ y' \\ z' \end{pmatrix} \quad (1.1)$$

The first transformation in (1.1) is called the *Lorentz transformation for the speed of the light source*, the second transformation is called the *Lorentz transformation to hyperbolic rotation angle* θ.

Here the symbols have the following significances.

1). c =const [$\frac{m}{\sec}$] is the speed of light in vacuum .

2). $t[\sec]$ is a time, $ct\,[m]$ is *time coordinate,* $x[m]$ is a *length,* $y[m]$ is *width,* $z[m]$ is a *height.*

3). $\bar{v} = \frac{v}{c}$ is a *normalized Lorentzian speed of the light source (dimensionless),* $|\bar{v}| < 1 \Leftrightarrow |v| < c$.

4). $v[\frac{m}{\sec}]$ is a *Lorentzian speed of the light source (the speed of uniform motion of the light source along the axis x).*

5). $\theta\,(-\infty < \theta < +\infty)$ is a *hyperbolic rotation angle (dimensionless).*

6). $sh(\theta)=\frac{e^{\theta}-e^{-\theta}}{2}$ is a *hyperbolic sine,* $ch(\theta)=\frac{e^{\theta}+e^{-\theta}}{2}$ is a *hyperbolic cosine*,

$th(\theta)=\frac{e^{\theta}-e^{-\theta}}{e^{\theta}+e^{-\theta}}$ is a *hyperbolic tangent,* $e=\lim\limits_{n\to+\infty}\left(1+\frac{1}{n}\right)^{n}\approx 2.71828$ is the *number of Napier*.

Because the conjugated matrices in (1.1) coincide, the following relationships follow from this fact:

$$\frac{\bar{v}}{\sqrt{1-(\bar{v})^{2}}}=sh(\theta),\ \frac{1}{\sqrt{1-(\bar{v})^{2}}}=ch(\theta),\ \bar{v}=\frac{v}{c}=\ th(\theta),\ v=c\bullet th(\theta) \tag{1.2}$$

Einstein proposed two postulates as the starting points of the *special theory of relativity.*

1.2. Einstein's postulates

1. *The principle of relativity* indicates the invariance of the laws of nature and the equations, which describe them, at the transition from one inertial system to another. That is, all inertial reference systems (IRS) are indistinguishable in their properties, and therefore no one of them cannot be selected as the preferred.
2. *The principle of the independence of light speed from the light source* claims that the light velocity c in vacuum is the same in all directions and is not dependent on the speed v of the movement of the light source. This implies that the light speed in vacuum must be limited and the same in all inertial reference systems.

Figure 1.1 presents the graph of the function $\bar{v}=\frac{v}{c}=th(\theta)$.

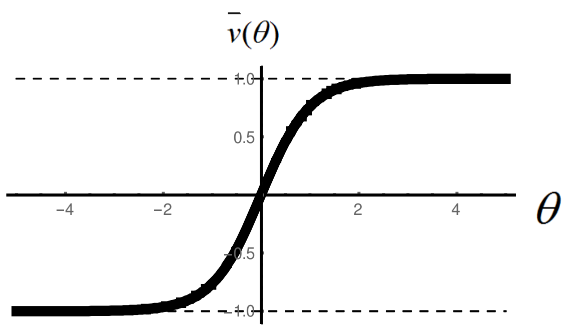

Figure 1.1. *The graph of the normalized speed of the light source* $\bar{v}(\theta)=\frac{v(\theta)}{c}=th(\theta)$ (the *black* curve), $\lim_{\theta\to\pm\infty}\bar{v}(\theta)=\pm 1$ are the limit values of the normalized speed of the light source (the *dashed* lines).

Adding to the spatial coordinates (*x, y, z*) the time coordinate $ct[m]$, we obtain the *four-dimensional space-time* $D^4=(ct,x,y,z)$. We supply the space $D^4=(ct,x,y,z)$ with the alternating *Minkowski metric*, where dl is the element of arc length.

$$(dl)^2=[d(ct)]^2-(dx)^2-(dy)^2-(dz)^2 \tag{1.3}$$

Minkowski metric (1.3) has the remarkable property of *invariance relatively* to the *Lorentz transformation* (1.1), that is

$$(dl)^2=[d(ct)]^2-(dx)^2-(dy)^2-(dz)^2=[d(ct')]^2-(dx')^2-(dy')^2-(dz')^2.$$

A number of well-known consequences of *special theory of relativity* (STR), the STR *relativistic effects* for moving light sources, compared with a stationary observer [11] follows from the invariance of the Minkowski metric relatively *Lorentz transformations*.

1.3. Relativistic effects of the classical special theory of relativity

1). *Time dilation* of the moving light source (*a time of the light source flows slowly compared to the stationary light source*).

2). *Shortening the length* of the moving light source (*the length of a moving light source is less than the length of the fixed light source*).

3). *Increasing the mass* of the moving light source (*the mass of the moving light source is greater than the mass of the fixed light source*).

4). *Increasing the energy* of the moving light source (the energy of the moving light source more than the energy of stationary light source)

2. Fibonacci special theory of relativity

2.1. Hyperbolic Fibonacci functions and the «golden" matrix

In [7,12,13,17,18] we have replaced the classical *Lorentz transformations* (1.1) of special theory of relativity on the *Fibonacci-Lorentz transformations*, which led us to the *Fibonacci special theory of relativity*.

The concepts of the *hyperbolic Fibonacci functions* and the "golden" matrices, introduced by Alexey Stakhov and Boris Rozin [9,19,20], are the sources for the creation of the *Fibonacci special theory of relativity* (FSTR). Recall these concepts.

Fibonacci hyperbolic sine:

$$sF(x)=\frac{\Phi^x-\Phi^{-x}}{\sqrt{5}}=\frac{2}{\sqrt{5}}sh(x\ln\Phi)$$

Fibonacci hyperbolic cosine:

$$cF(x)=\frac{\Phi^x+\Phi^{-x}}{\sqrt{5}}=\frac{2}{\sqrt{5}}ch(x\ln\Phi)$$

The Golden Ratio:

$$\Phi=\frac{1+\sqrt{5}}{2}\approx 1.61803$$

The basic relation:

$$\left[cF(x-1)\right]^2-sF(x-2)sF(x)=1 \tag{2.1}$$

The "golden" matrix *A*:

$$A=\begin{pmatrix} cF(x-1) & sF(x-2) \\ sF(x) & cF(x-1)\end{pmatrix}=\begin{pmatrix} \frac{2}{\sqrt{5}}ch[(x-1)\bullet\ln\Phi] & \frac{2}{\sqrt{5}}sh[(x-2)\bullet\ln\Phi)] \\ \frac{2}{\sqrt{5}}sh(x\bullet\ln\Phi] & \frac{2}{\sqrt{5}}ch[(x-1)\bullet\ln\Phi] \end{pmatrix};\ \det(A)=1. \tag{2.2}$$

2.2. Fibonacci-Lorenz transformations and Fibonacci special theory of relativity

Fibonacci special theory of relativity, set forth in [7,12,13,17,18] is based on the following *Fibonacci-Lorentz transformations*:

$$\begin{pmatrix} c_0t \\ x \\ y \\ z \end{pmatrix}=\begin{pmatrix} \frac{1}{\sqrt{1-(\bar{v})^2}} & \frac{1}{\bar{c}(\psi)}\frac{\bar{v}}{\sqrt{1-(\bar{v})^2}} & 0 & 0 \\ \bar{c}(\psi)\frac{\bar{v}}{\sqrt{1-(\bar{v})^2}} & \frac{1}{\sqrt{1-(\bar{v})^2}} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}\bullet\begin{pmatrix} c_0t' \\ x' \\ y' \\ z' \end{pmatrix},\quad \begin{pmatrix} c_0t \\ x \\ y \\ z \end{pmatrix}=\begin{pmatrix} cF(\psi-1) & sF(\psi-2) & 0 & 0 \\ sF(\psi) & cF(\psi-1) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}\bullet\begin{pmatrix} c_0t' \\ x' \\ y' \\ z' \end{pmatrix} \tag{2.3}$$

2.3. The main postulate of the Fibonacci special theory of relativity

For the *Fibonacci special theory of relativity*, **the velocity of light in vacuum is not constant**, but is determined by the function $c = \bar{c}(\psi) \bullet c_0[\frac{m}{\sec}]$. The postulate on variability of the light speed "*c*" in a vacuum is consistent with information, gathered by the astronomer **John Webb** (www.vokrugsveta.ru/telegraph/cosmos/1298).

He found that the light, which is coming to us from the observed Universe, obeys to *the principle of non-decreasing of entropy*; this means, that for this case the *Second Law of Thermodynamics* has been saved and therefore *the light speed "c" should decrease with increasing of the Universe age.* **James Franson's** article [21] supports this conclusion.

2.4. The significances of symbols for the Fibonacci special theory of relativity

1). The dimensionless parameter ψ means *the angle of the Fibonacci rotation* (or according to another terminology [17], the parameter ψ is called the *parameter of self-organization*). We will use in our article both the first and second definitions.

2). $c_0 = \frac{c*}{\Phi}\left[\frac{m}{\sec}\right]$=const means the *normalized Lorentzian speed of light in vacuum.* Here $c*\left[\frac{m}{\sec}\right]$=const is the speed of light in vacuum for the case of the classical special theory of relativity. For the modern period it is accepted the following value for $c*$:

$$c* \approx 2.99\,792\,458 \bullet 10^8\left[\frac{m}{\sec}\right].$$

The value of c_0 does not depend on the speed movement of the light source or the observer, and is the same for all inertial reference systems. For the modern period we have:

$$c_0 = \frac{c*}{\Phi} \approx 1.85\,281\,990 \bullet 10^8\left[\frac{m}{\sec}\right].$$

3). The dimensionless parameter $\bar{c}(\psi)=\sqrt{\frac{sF(\psi)}{sF(\psi-2)}}=\frac{\sqrt{[cF(\psi-1)]^2-1}}{|sF(\psi-2)|}$ is called the *normalized Fibonacci speed of light in vacuum.*

4). The parameter $v(\psi)=c(\psi)\bullet\bar{v}(\psi)\;=c_0\bullet\frac{sF(\psi)}{cF(\psi-1)}\left[\frac{m}{\sec}\right]$ is called the *Fibonacci speed of the light source in vacuum.*

5). The dimensionless parameter $\bar{v}(\psi)=\frac{1}{\bar{c}(\psi)}\bullet\frac{sF(\psi)}{cF(\psi-1)}=\frac{|\psi|}{\psi}\bullet\frac{\sqrt{[cF(\psi-1)]^2-1}}{cF(\psi-1)}$

is called the *normalized Fibonacci speed of the light source in vacuum.*

Proof. From coincidence of the conjugating matrices in (2.3), we get:

$$\frac{1}{\sqrt{1-(\bar{v})^2}}=cF(\psi-1),\quad \bar{c}(\psi)\frac{\bar{v}}{\sqrt{1-(\bar{v})^2}}=sF(\psi).$$

Hence, we have: $\bar{v}=\bar{v}(\psi)$.

To find the explicit form of the dependence $\bar{v}=\bar{v}(\psi)$, we divide the second above-mentioned relation on the first relation. Then we have:

$$\frac{\bar{c}(\psi)\dfrac{\bar{v}(\psi)}{\sqrt{1-[\bar{v}(\psi)]^2}}}{\dfrac{1}{\sqrt{1-[\bar{v}(\psi)]^2}}}=\frac{sF(\psi)}{cF(\psi-1)}.$$

Hence, after the reduction by $\sqrt{1-[\bar{v}(\psi)]^2}$, we get:

$$\bar{v}(\psi)=\frac{1}{\bar{c}(\psi)}\bullet\frac{sF(\psi)}{cF(\psi-1)}.$$

Since

$$\bar{c}(\psi)=\sqrt{\frac{sF(\psi)}{sF(\psi-2)}}=\frac{\sqrt{[cF(\psi-1)]^2-1}}{|sF(\psi-2)|},$$

then

$$\bar{v}(\psi)=\frac{1}{\bar{c}(\psi)}\bullet\frac{sF(\psi)}{cF(\psi-1)}=\sqrt{\frac{sF(\psi-2)}{sF(\psi)}}\bullet\frac{sF(\psi)}{cF(\psi-1)}=$$

$$=\sigma(\psi)\bullet\sqrt{\frac{[sFs(\psi-2)][sF(\psi)]^2}{sFs(\psi)}}\bullet\frac{1}{cF(\psi-1)}==\sigma(\psi)\bullet\sqrt{sF(\psi-2)\bullet sF(\psi)}\bullet\frac{1}{cF(\psi-1)}.$$

Here $\sigma(\psi)$ is the sign $\sigma(\psi)=$ sign $[sF(\psi)]$ of the function:

$$sF(\psi)=\frac{\Phi^{\psi}-\Phi^{-\psi}}{\sqrt{5}}=\frac{2}{\sqrt{5}}sh(\psi\ln\Phi).$$

Hence, it follows that

$$\sigma(\psi)=\frac{|\psi|}{\psi},$$

Furthermore, from the basic relation (2.1)

$$[cF(\psi-1)]^2-sF(\psi-2)sF(\psi)=1$$

we get:

$$sF(\psi-2)sF(\psi)=[cF(\psi-1)]^2-1.$$

But then for $\bar{v}(\psi)$ we have:

$$\bar{v}(\psi)=\frac{1}{\bar{c}(\psi)}\bullet\frac{sF(\psi)}{cF(\psi-1)}=\sigma(\psi)\bullet\sqrt{sF(\psi-2)\bullet sF(\psi)}\bullet\frac{1}{cF(\psi-1)}=\frac{|\psi|}{\psi}\frac{\sqrt{[cF(\psi-1)-1]^2}}{cF(\psi-1)}$$

,

what it is required to prove.

2.5. Properties of the normalized Fibonacci light speed

For the *normalized Fibonacci speed of light in vacuum* $\bar{c}(\psi)=\sqrt{\frac{sF(\psi)}{sF(\psi-2)}}$ the following properties are fulfilled:

1). For the values $\{-\infty<\psi<0\}$ we have $sF(\psi)<0, sF(\psi-2)<0,$ but for the values $\{2<\psi<+\infty\}$ we have $sF(\psi)>0, sF(\psi-2)>0.$ Therefore, when $\{-\infty<\psi<0\}\cup\{2<\psi<+\infty\}$ we get, that $\frac{sF(\psi)}{sF(\psi-2)}>0$, and, therefore, $\bar{c}(\psi)=\sqrt{\frac{sF(\psi)}{sF(\psi-2)}}>0$.

For such values ψ the following limit values are fulfilled:

$$\bar{c}(\psi=-\infty)=\frac{1}{\Phi},\ \bar{c}(\psi=0-0)=0,\ \bar{c}(\psi=2+0)=+\infty,\ \bar{c}(\psi=+\infty)=\Phi. \qquad (2.4)$$

Hence, we obtain the following limit values for the Fibonacci light speed in vacuum:

$$\lim_{\psi\to+\infty} c=\lim_{\psi\to+\infty}\bar{c}(\psi)\bullet c_0=\Phi\bullet\frac{c^*}{\Phi}=c^*,\ \lim_{\psi\to-\infty} c=\lim_{\psi\to-\infty}\bar{c}(\psi)\bullet c_0=\frac{1}{\Phi}\bullet\frac{c^*}{\Phi}=\frac{c^*}{\Phi^2}. \qquad (2.5)$$

2). For the values $\{0<\psi<2\}$ we have: $sF(\psi)>0, sF(\psi-2)<0$. Therefore for the case $\{0<\psi<2\}$ we have: $\frac{sF(\psi)}{sF(\psi-2)}<0$. But then $\bar{c}(\psi)=i\bullet\left|\bar{c}(\psi\right|$, where the absolute value $\left|\bar{c}(\psi\right|=\sqrt{-\frac{sF(\psi)}{sF(\psi-2)}}>0.\cdot$

For such values of ψ for the case of the absolute values $\left|\bar{c}(\psi)\right|$ the following limit values are fulfilled:

$$\left|\bar{c}(\psi=0+0)\right|=0, \left|\bar{c}(\psi=2-0)\right|=+\infty. \qquad (2.6)$$

3). The values $\psi=0$ and $\psi=2$ correspond bifurcation points (see Fig. 2.1).

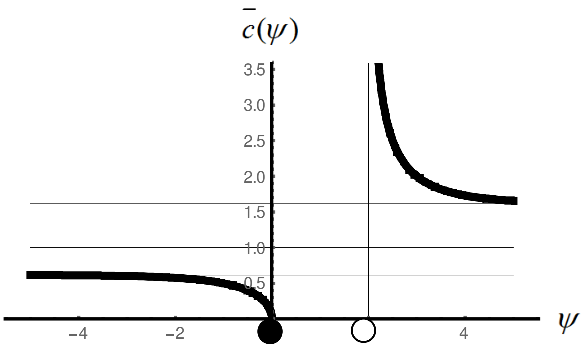

Figure 2.1. *The graph* $\bar{c}(\psi)>0$ *for the case* $\{-\infty<\psi<0\}\cup\{2<\psi<+\infty\}$ (*the black curve*).

2.6. Identical types of symbols for Fibonacci special theory of relativity

1). *The normalized Fibonacci light speed in vacuum* $\bar{c}(\psi)=\sqrt{\frac{sF(\psi)}{sF(\psi-2)}}$ are derived directly from the equality of the conjugating matrices in (2.3).

Then we get:

$$\begin{cases} \dfrac{1}{\sqrt{1-\left(\bar{v}\right)^2}} = cF(\psi-1), \dfrac{1}{\bar{c}(\psi)}\dfrac{\bar{v}}{\sqrt{1-\left(\bar{v}\right)^2}} = sF(\psi-2), \\ \bar{c}(\psi)\dfrac{\bar{v}}{\sqrt{1-\left(\bar{v}\right)^2}} = sF(\psi). \end{cases} \tag{2.7}$$

Hence we have:

$$\frac{\bar{v}}{\sqrt{1-\left(\bar{v}\right)^2}} = \bar{c}(\psi)\bullet sF(\psi-2) = \frac{1}{\bar{c}(\psi)}\bullet sF(\psi) \Rightarrow \left[\bar{c}(\psi)\right]^2 = \frac{sF(\psi)}{sF(\psi-2)} \Rightarrow \bar{c}(\psi) = \sqrt{\frac{sF(\psi)}{sF(\psi-2)}}.$$

2). From the formulas $\bar{c}(\psi) = \sqrt{\dfrac{sF(\psi)}{sF(\psi-2)}}$, $sF(\psi)\bullet sF(\psi-2) = [cF(\psi-1)]^2 - 1$ (see. (2.1)) we get an identical form for $\bar{c}(\psi)$. Then, we have:

$$\bar{c}(\psi) = \sqrt{\frac{sF(\psi)}{sF(\psi-2)}} = \sqrt{\frac{sF(\psi)sF(\psi-2)}{[sF(\psi-2)]^2}}; \sqrt{\frac{sF(\psi)sF(\psi-2)}{[sF(\psi-2)]^2}} = \frac{\sqrt{[cF(\psi-1)]^2-1}}{|sF(\psi-2)|}.$$

From here, we get for $\bar{c}(\psi)$ the following identical form:

$$\bar{c}(\psi) = \frac{\sqrt{[cF(\psi-1)]^2-1}}{|sF(\psi-2)|}. \tag{2.8}$$

3). From the relations

$$\frac{1}{\sqrt{1-\left(\bar{v}\right)^2}} = cF(\psi-1), \frac{\bar{v}}{\sqrt{1-\left(\bar{v}\right)^2}} = \bar{c}(\psi)\bullet sF(\psi-2) = \frac{1}{\bar{c}(\psi)}\bullet sF(\psi), \ \bar{c}(\psi) = \sqrt{\frac{sF(\psi)}{sF(\psi-2)}}$$

we get the identical form for $\bar{v}(\psi)$ as follows:

$$3.1). \frac{\bar{v}}{\sqrt{1-\left(\bar{v}\right)^2}} = \frac{1}{\bar{c}(\psi)}\bullet sF(\psi) = \sqrt{\frac{sF(\psi-2)}{sF(\psi)}}\bullet sF(\psi) = \frac{|\psi|}{\psi}\bullet\sqrt{\frac{sF(\psi-2)sF[\psi]^2}{sF(\psi)}} =$$

$$= \frac{|\psi|}{\psi}\sqrt{sF(\psi-2)\bullet sF(\psi)} = \frac{|\psi|}{\psi}\bullet\sqrt{[cF(\psi-1)]^2-1}.$$

$$3.2). \frac{\bar{v}}{\sqrt{1-\left(\bar{v}\right)^2}} = \bar{c}(\psi)\bullet sF(\psi-2) = \sqrt{\frac{sF(\psi)}{sF(\psi-2)}}\bullet sF(\psi-2) = \frac{|\psi|}{\psi}\sqrt{\frac{sF(\psi)\left[sF(\psi-2)\right]^2}{sF(\psi-2)}} =$$

$$=\frac{|\psi|}{\psi}\sqrt{sF(\psi)\bullet sF(\psi-2)}=\frac{|\psi|}{\psi}\bullet\sqrt{[cF(\psi-1)]^2-1}.$$

3.3) . $$\frac{\dfrac{\bar{v}}{\sqrt{1-\left(\bar{v}\right)^2}}}{\dfrac{1}{\sqrt{1-\left(\bar{v}\right)^2}}}=\bar{v}=\frac{|\psi|}{\psi}\bullet\frac{\sqrt{[cF(\psi-1)]^2-1}}{cF(\psi-1)}.$$

Hence, we get the following formula for the *normalized Fibonacci speed of the source of light in vacuum:*

$$\bar{v}(\psi)=\frac{|\psi|}{\psi}\bullet\frac{\sqrt{[cF(\psi-1)]^2-1}}{cF(\psi-1)} \qquad (2.9)$$

Using (2.3), we rewrite (2.9) as follows:

$$\frac{1}{\sqrt{1-\left(\bar{v}\right)^2}}=cF(\psi-1),\ \bar{c}(\psi)\frac{\bar{v}}{\sqrt{1-\left(\bar{v}\right)^2}}=sF(\psi),\quad sF(\psi)=\bar{c}(\psi)\frac{\bar{v}}{\sqrt{1-\left(\bar{v}\right)^2}}=\bar{c}(\psi)\ \bar{v}\bullet cF(\psi-1).$$

Hence, for the *Fibonacci normalized speed of the light source in vacuum* we get the following formula:

$$\bar{v}(\psi)=\frac{1}{\bar{c}(\psi)}\bullet\frac{sF(\psi)}{cF(\psi-1)}. \qquad (2.10)$$

3). Then the formula $v=\bar{c}(\psi)\ c_0\bullet\bar{v}$ is transformed as follows. Since

$$v(\psi)=\bar{c}(\psi)\ c_0\bullet\bar{v}(\psi)\ \text{and}\ \bar{v}(\psi)=\frac{1}{\bar{c}(\psi)}\bullet\frac{sF(\psi)}{cF(\psi-1)}, \qquad (2.10\text{-a})$$

then we have:

$$v(\psi)=\bar{c}(\psi)\ c_0\bullet\bar{v}(\psi)=\bar{c}(\psi)\ c_0\bullet\frac{1}{\bar{c}(\psi)}\bullet\frac{sF(\psi)}{cF(\psi-1)}=c_0\bullet\frac{sF(\psi)}{cF(\psi-1)}. \qquad (2.10\text{-b})$$

Hence, for the Fibonacci speed of light source in vacuum $v(\psi)$, we get the following formula:

$$v(\psi)=C_0\bullet v(\psi)=c_0\bullet\frac{sF(\psi)}{cF(\psi-1)}. \qquad (2.11)$$

Fig. 2.2 shows the graphs $\bar{c}(\psi)$ and $\bar{v}(\psi)$.

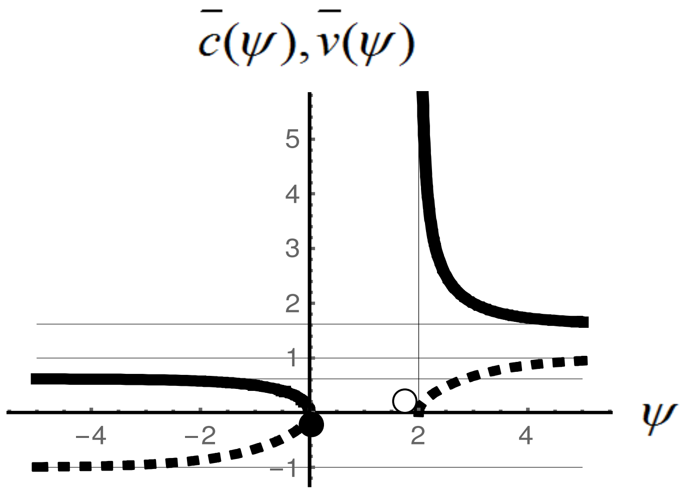

Figure 2.2 . *The graph* $\bar{c}(\psi)$ *(*the *black* curves*) and the graph* $\bar{v}(\psi)$ *(*the *dashed* curves)*,where the parameter* ψ *is in limits* $\{-\infty < \psi < 0\} \cup \{2 < \psi < +\infty\}$. *The symbols* ● *and* ○ *correspond to the bifurcation points* $\psi = 0$ *and* $\psi = 2$.

2.7. The physical interpretation of the mathematical model of the Fibonacci special theory of relativity

In this section, the authors used the works [7,12,13,17,18].

2.7.1. Bifurcation Points, Material Universe, Dark and Light Ages, Black Hole and Anti-matter. Let us interpret Fig.2.2 from physical point of view:

1). The point $\psi = 0$ is the *first point of bifurcation* and corresponds to the *point of singularity*, the "Big Bang."

2). The domain $\{0 < \psi < +\infty\}$ (the right half of the graph in Fig. 5.2) corresponds to the *Material Universe*"; this domain is divided by the second bifurcation point $\psi = 2$ into two sub-domains:

a_1) the sub-domain $\{0 < \psi < 2\}$ or the *Dark Ages*, when there was nobody to illuminate the Universe.. In the sub-domain $\{0 < \psi < 2\}$ the *normalized Fibonacci velocity of light in vacuum* $\bar{c}(\psi)$ is an **imaginary** magnitude, although the *Material Universe* became to evolve and elementary particles began to be formed;

a_2)_the second point of bifurcation_ψ=2 corresponds to the beginning of the transition from the *Dark Ages* to the *Light Ages*;

a_3) the sub-domain $\{2<\psi<+\infty\}$ means *Light Ages*, when the first proto-stars lighted up and the *Light Universe* began to evolve up to the present day;

3).The domain $\{-\infty<\psi<0\}$ (the left half of the graph in Fig. 2.2) corresponds to the *Black Hole*, which consists from *Anti-matter*.

2.7.2. Fibonacci-Lorentz transformations for the Dark Ages $\{0<\psi<2\}$. For this case we get, that $\frac{|\psi|}{\psi}=1$ and $[cF(\psi-1)]^2-1<0$. Because for all values $\{0<\psi<2\}$ the following non-equality is fulfilled: $[cF(\psi-1)]^2-1<0$, then for the *Dark Ages* the following properties are fulfilled:

1). The *normalized Fibonacci speed of light in vacuum* $\bar{c}(\psi)=i\bullet\frac{\sqrt{1-[cF(\psi-1)]^2}}{|sF(\psi-2)|}$ is an *imaginary number*, the *normalized Fibonacci speed of light in vacuum*

$$c(\psi)=i\bullet\frac{\sqrt{1-[cF(\psi-1)]^2}}{|sF(\psi-2)|}\bullet c_0\left[\frac{m}{\sec}\right]$$

is an *imaginary number*.

2). The *normalized Fibonacci speed of the light source in vacuum* $\bar{v}(\psi)=i\bullet\frac{\sqrt{[1-cF(\psi-1)]^2}}{cF(\psi-1)}$ is an *imaginary number*, the *Fibonacci speed of the light source in vacuum* $v(\psi)=c_0\bullet\frac{sF(\psi)}{cF(\psi-1)}\left[\frac{m}{\sec}\right]$ is a *real number*.

Table 2.1. Numerical characteristics $\bar{c}(\psi)$ and $\bar{v}(\psi)$ in dependence from the parameter of self-organization ψ for the range $\{-\infty<\psi<+\infty\}$

The dimensionless magnitudes	**The Black Hole (the negative arrow of time)** $\{-\infty<\psi<0\}$				**The Dark Ages** $\{0<\psi<2\}$					**The Light Ages (the positive arrow of time)** $\{2<\psi<+\infty\}$		
Parameter of self-organization ψ	$-\infty$	**-5**	**-1**	**0**	**0**	**0.5**	**1**	**1.5**	**2-0**	**2+0**	**3**	$+\infty$
The Normalized Fibonacci	**0.618**	**0.615**	**0.5**	**0**	**0**	**0.555** $\bullet i$	**1** $\bullet i$	**1.798** $\bullet i$	$\infty\bullet i$	$+\infty$	**2**	**1.618**

speed of light vacuum $\bar{c}(\psi)$												
The normalized Fibonacci speed of the light source in vacuum $\bar{v}(\psi)$	**-1**	**-0.992**	**-0.666**	**0**	**0**	**0.424** $\bullet\, i$	**0.5** $\bullet\, i$	**0.424** $\bullet\, i$	**0**	**0**	**0.666**	**1**

Previously we have presented in Fig. 2.1 and 2.2 the graphs of the real dimensionless functions $\bar{c}(\psi), \bar{v}(\psi)$ as for the *Black Hole* $\{-\infty < \psi < 0\}$ and for the *Light Ages* $\{2 < \psi < +\infty\}$.

For the *Dark Ages* $\{0 < \psi < 2\}$, the functions $\bar{c}(\psi), \bar{v}(\psi)$ are imaginary and has the following form $\bar{c}(\psi) = |\bar{c}(\psi)| \bullet i$, $\bar{v}(\psi) = |\bar{v}(\psi)| \bullet i$. That is why, the Fig, 2.3 and 2.4 represent for the *Dark Ages* the graphs of the *modules* $|\bar{c}(\psi|$ and $|\bar{v}(\psi|$, which are positive dimensionless real functions.

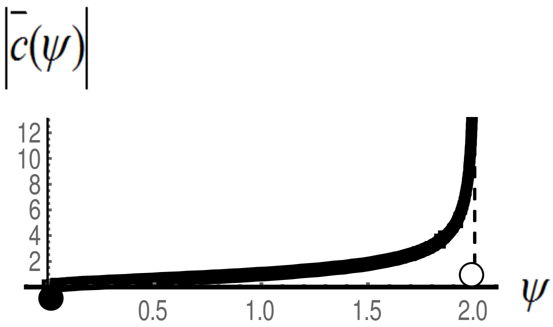

Figure 2.3. *The graph of the module* $|\bar{c}(\psi|$ *in the range* $\{0 < \psi < 2\}$.

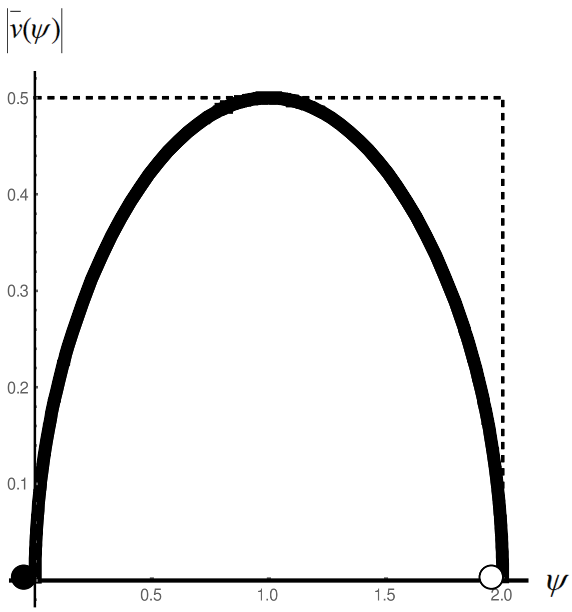

Figure 2.4. *The graph of the module* $|\bar{v}(\psi)|$ *on the interval* $\{0<\psi<2\}$.

The further strategy of this article consists in the following. By using the mathematical model of the *Fibonacci special theory of relativity*, we will try to establish the interconnection between the dimensionless *parameter of self-organization* and the age of the Universe at any given time T $[mlrd.years]$ starting since the *Big Bang*.

This will allow to interpret fully the above mathematical model of the evolution of the Universe not only qualitatively but also quantitatively as both for the positive arrow of time ($T>0$), and for the negative arrow of time ($T<0$).

To solve this problem, we need to study the problem of dependence of the dimensionless constant (the *fine structure constant*) from the *Universe age*, starting since the *Big Bang*.

For example, for the *present time*, according to studies of the CMB, the *Universe age* is $T_{present}=13.81[billion\ years]$ (the data of WMAP for 2012 [22]) or more accurate value $T_{present}=13.81\pm0.06[billion\ years]$ (the data of PLANCK for 2013 [23]), and the value of the *fine structure constant* is equal to $\alpha=0.0072973525376$.

3. The fine-structure constant α and its relationship with the evolution of the Universe

3.1. The fine-structure constant

The problem of the *fine-structure constant* is one of the 10 most important physical- mathematical problems, which are called *Millennium Problems* [5, 6, 24-29].

According to astronomical observations, the constant α for the Universe remains **almost unchanged** for many milliards of years after the *Big Bang* and ensures sustainable functioning of the Universe, and therefore this constant is named the *genetic code of the Universe*.

The numerical value of this dimensionless constant α is:

$$\alpha = \frac{e^2}{2\varepsilon_0 c \bullet \bar{h}} = \frac{1}{137.035999679} = 7.2973525376 \times 10^{-3}, \qquad (3.1)$$

where ε_0 is *electric constant* ; $\hbar$ is *Dirac's constant*; c =const [$\frac{m}{\sec}$] is the speed of light in vacuum; e is *elementary charge* .

According to CODATA-2014 (http://www.codata.org), the recommended value of the *fine-structure constant* is equal:

$$\alpha = \frac{1}{137.035999139} = 7.2973525664 \times 10^{-3}.$$

Among these problems, the problem of *the fine-structure constant* is included by David Gross into his formulation of the First Physics MILLENNIA PROBLEM [5,6, 24-29].

3.2. The significances of symbols for the fine-structure constant α

1). *Electric constant* (or in other terminology *dielectric permeability of vacuum*)

$$\varepsilon_0 = 8.854187817620 \times 10^{-12} \left[\frac{A^2 \bullet c^4}{m^3 \bullet Kg}\right], \qquad (3.2)$$

where *A* (*amper*) is an unit amperage (SI), c=2.99 792 458 • $10^8 \left[\frac{m}{\sec}\right]$ is an *velocity of the light in vacuum.*

2). *Dirac's constant* (or in other terms, the *reduced Planck's constant*)

$$\bar{h} = \frac{h}{2\pi} = 1.05\,457\,1628 \times 10^{-34}\ [J \bullet sec], \qquad (3.3)$$

where h=6.626068959046 $\times 10^{-34}$ [$J \bullet sec$] is *Planck's constant* (or in other terms, the *quantum of action*), J (*Joule*) is a unit of work, power and heat quantity (SI).

3). *Elementary charge e.* In quantum mechanics, the *elementary charge* is considered as a minimal portion (*quantum*) of electrical charge

$$e = 1.6022176487 \times 10^{-19}\ [Cal], \qquad (3.4)$$

where *Cal* is the off-system unit of heat amount in the system SI, 1 *Cal* = 4,1868 *J*

3.3. Patrimony into discovery of the fine-structure constant

The fine-structure constant α is a fundamental physical constant, which characterizes the power of the electromagnetic interaction. It characterizes not separate physical bodies, but the physical properties of our world in the whole.

For the first time, the constant α has been described in 1916 by the German physicist Arnold Sommerfeld as a measure of the relativistic corrections in the description of atomic spectral lines of atoms in the model of the Danish physicist Niels Bohr. In other words, the *fine-structure constant* α describes the splitting of atomic levels on a few close sublevels (*multiplets*) due to the effects of special relativity. A similar statement about the constant α also belongs to the American physicist Richard Feynman. The more detailed information for the physical comprehension of α can be found in James Carter's book [27].

3.4. The hypotheses and experiments about variability of the fine structure constant, depending on the Universe age

Studying the question of whether is the fine structure constant really fundamental physical constant, that is, it always was unchanged or it possibly changed during the existence of the Universe, has a long history.

In 1995, the prominent Russian physicist Lev Landau predicted that *this constant can vary depending on the time.* However, such changes *can not be very large*, *"otherwise they would have already "emerged "in relatively simple experiments."*

In the late 1990s, new data from astronomical observations appeared. Astronomer John Webb and his colleagues http://www.phys.unsw.edu.au/~jkw/alpha/Welcome.html) found a tiny change in the wavelength of the light from the distant quasars. Simulation of quasars light showed that 10 to 12 billion years ago, the value of the constant α was greater than the current value.

More detailed observations of quasars, made in April 2004 by using the 8.2-meter telescope in Paranal Observatory in Chile, showed that over 10 billion years ago, the possible value of the constant α could not be more than 6×10^{-7} of the present value of α.

3.5. Sixth Hilbert's Problem and recommendations to solving physical problems by means of harmony between the experience and thinking

It should be noted that already in 1900, **David Hilbert** in the speech "Mathematical problems" [1-3], made at the Second International Congress of Mathematicians in Paris (August 8, 1900), has formulated the Sixth Problem *"Mathematical treatment of the axioms of physics"*.

In the Sixth Problem he drew attention not only on the study of the physical phenomena and constants by using experiments, but also on the creation of rigorous mathematical theories, which are directed on solving of physical problems, by using the *"realm of pure thought."*

In the Sixth Problem, David Hilbert put forward for mathematicians the following problem:

«The investigations on the foundations of geometry suggest the problem: To treat in the same manner, by means of axioms, those physical sciences in which mathematics plays an important part»

In the **Sixth Problem** Hilbert says:

« Further, the mathematician has the duty to test exactly in each instance whether the new axioms are compatible with the previous ones. The physicist, as his theories develop, often finds himself forced by the results of his experiments to make new hypotheses, while he depends, with respect to the compatibility of the new hypotheses with the old axioms, solely upon these experiments or upon a certain physical intuition, a practice which in the rigorously logical building up of a theory is not admissible. The desired proof of the compatibility of all assumptions seems to me also of importance,

because the effort to obtain such proof always forces us most effectually to an exact formulation of the axioms.

The physicist, as his theories develop, often finds himself forced by the results of his experiments to make new hypotheses, while he depends, with respect to the compatibility of the new hypotheses with the old axioms, solely upon these experiments or upon a certain physical intuition, a practice which in the rigorously logical building up of a theory is not admissible….»

In the Introductory part of his report, Hilbert says :

«But, in the further development of a branch of mathematics, the human mind, encouraged by the success of its solutions, becomes conscious of its independence. It evolves from itself alone, often without appreciable influence from without, by means of logical combination, generalization, specialization, by separating and collecting ideas in fortunate ways, new and fruitful problems, and appears then itself as the real questioner... In the meantime, while the creative power of pure reason is at work, the outer world again comes into play, forces upon us new questions from actual experience, opens up new branches of mathematics, and while we seek to conquer these new fields of knowledge for the realm of pure thought, we often find the answers to old unsolved problems and thus at the same time advance most successfully the old theories. And it seems to me that the numerous and surprising analogies and that apparently prearranged ***harmony*** *which the mathematician so often perceives in the questions, methods and ideas of the various branches of his science, have their origin in this ever-recurring interplay between thought and experience.*»

Thus, a priori, even Hilbert himself points out that *the Sixth Problem is too vague and virtually impracticable* and, therefore, a mathematical statement of the axioms of physics is inherently unsound. That is why, *Hilbert's Sixth Problem "Mathematical treatment of the axioms of physics"* hadn't attracted for attention of mathematicians.

However, the importance of Hilbert's Sixth Problem is the fact that Hilbert suggests to solve physical problem by constructing special mathematical theory. That is, Hilbert's Sixth Problem is *physical,* but its solution is considered as a *mathematical.*

3.6. Formula by Nikolai Kosinov on the interconnection of three major dimensionless constants: the fine structure constant α, the number π and the golden ratio Φ

The works by the Ukrainian physicist Nikolai Kosinov [24],[28], [29] became an important breakthrough in the *"understanding of geometrical status of the fine-structure constant, and also that all dimensionless parameters, which characterize the micro world and universe, are calculable in principle."*

In 2000, Nikolai Kosinov [24] found a simple and beautiful relationship linking dimensionless constants: the fine structure constant α, *the number of* π and the *golden ratio* $\Phi = \frac{1+\sqrt{5}}{2}$. This formula looks as follows:

$$\alpha = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times \Phi^{\frac{7}{130}}. \tag{3.5}$$

The new calculated value of the *fine-structure constant* was obtained in [24] on the basis of formula (3.5):

$$\alpha = 7.297351997351997377362 \times 10^{-3}. \tag{3.6}$$

Since 2014, the recommended SODATA (http://www.codata.org) value of the fine-structure constant is as follows

$$\alpha = \frac{1}{137.035999139} = 7.2973525664 \times 10^{-3} \quad \text{(dimensionless)}.$$

Thus, the absolute error $\Delta\alpha$ between the true and estimated values of α is equal to:

$$\begin{aligned} \Delta\alpha &= \left|7.2973525664\times10^{-3} - 7.2973519973\times10^{-3}\right|. \\ &= 5.691\times10^{-10} = 0.0000000005691 \end{aligned} \tag{3.7}$$

The relative error $\frac{\Delta\alpha}{\alpha}$ in this case, equal to:

$$\frac{\Delta\alpha}{\alpha} = \frac{5.691\times10^{-10}}{7.2973525376\times10^{-3}} = 7.779872\times10^{-8} = 0.0000000779872, \tag{3.8}$$

that is, Kosinov's formula [24] actually coincides with the recommended CODATA value of the fine-structure constant.

3.7. Postulate of the dependence of the fine-structure constant from the Universe age for the mathematical model of the Fibonacci special theory of relativity

The presence in the formula (3.5) of the *golden ratio*, which is known to be the indicator of *mathematical harmony*, starting with the ancient Greeks, led the authors of the present article to the usage of the *Fibonacci special theory of relativity*, based on the golden ratio, for the theoretical study of the variations of the *fine-structure constant* depending on the time evolution of the Universe age up to the present time $T_{\text{present}} = 13.75 \pm 0{,}13$ [*billion years*] according to the data of WMAP [22] or according to the specified data of PLANCK [23] $T_{\text{present}} = 13.81 \pm 0.06$ [*billion years*], starting since *Big Bang*.

To this end, we introduce into consideration the following postulate:

The fine structure constant α depends on the time T [billion years], counted from the moment of the "Big Bang" (T = 0) for Dark and Light Ages (T> 0), and for the "Black Hole" (T <0) by the formula:

$$\alpha = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times \left|\bar{c}(\psi)\right|^{\frac{7}{130}}, \quad \psi = \lambda_0 \bullet T . \tag{3.9}$$

3.8. Significances of symbols in formula for the fine-structure constant, depending on the age of the Universe

1). T [*billion years*] is the time counted from the moment of the *Big Bang*.

2). $\lambda_0 \left[\dfrac{1}{billion\ years}\right] = const > 0$ is a *weight coefficient*.

3). $\bar{c}(\psi) = \sqrt{\dfrac{sF(\psi)}{sF(\psi-2)}} = \dfrac{\sqrt{\left[cF(\psi-1)\right]^2 - 1}}{\left|sF(\psi-2)\right|}$ (dimensionless) is the *normalized Fibonacci speed of light in vacuum,* $\left|\bar{c}(\psi)\right|$ is the *module of the normalized Fibonacci speed of light in vacuum,* ψ is a *parameter of self-organization*.

Note that $\bar{c}(\psi) = \left|\bar{c}(\psi)\right|$ for the range $\{-\infty < \psi < 0\} \cup \{2 < \psi < +\infty\}$, and $\bar{c}(\psi) = i \bullet \left|\bar{c}(\psi)\right|$ for the range $\{0 < \psi < 2\}$, where $i = \sqrt{-1}$ is imaginary unit. The values $\psi = 0$ and $\psi = 2$ are the *bifurcation values* for $\bar{c}(\psi)$. For ψ and $\left|\bar{c}(\psi)\right|$ we have the following restrictions:

$\{2 < \psi < +\infty\}$ (the *Light Ages*) for the range $\{\Phi < |\bar{c}(\psi)| < +\infty\}$,

$\{0 < \psi < 2\}$ (the *Dark Ages*) for the range $\{0 < |\bar{c}(\psi)| < +\infty\}$,

$\{-\infty < \psi < 0\}$ (the *Black Hole*) for the range $\{0 < |\bar{c}(\psi)| < \Phi^{-1}\}$.

4). $sF(x) = \frac{\Phi^x - \Phi^{-x}}{\sqrt{5}} = \frac{2}{\sqrt{5}} sh(x \bullet \ln \Phi)$ (dimensionless) is the *hyperbolic Fibonacci sine,* $cF(x) = \frac{\Phi^x + \Phi^{-x}}{\sqrt{5}} = \frac{2}{\sqrt{5}} ch(x \bullet \ln \Phi)$ (dimensionless) is the *hyperbolic Fibonacci cosine.*

5). $\Phi = \frac{1+\sqrt{5}}{2} \approx 1.61803$ (dimensionless) is the *golden ratio*.

3.9. The procedure for finding the numerical values of the weighting factor in the postulate of the dependence of the fine-structure constant from the Universe age

1). *Experimentally* as a result of astronomical observations, or other experience we find for the *Light Ages* the *supporting experiment* for the case $(T_0 > 0, \alpha_0 > 0)$, where $T_0[\textit{billion years}] > 0$ is the fixed value of the time T, measured from the moment of the *Big Bang* and $\alpha_0 > 0$ is the value of the *fine-structure constant* in the moment of time T_0.

2). From the formula (3.9) for the case $\alpha_0 > 0$, we calculate the corresponding value of the *normalized Fibonacci speed of light* in vacuum:

$$\bar{c}(\psi_0) = |\bar{c}(\psi_0)| = \sqrt[14]{10^{559} \bullet \pi^{-1}} \bullet \sqrt[7]{\alpha_0^{130}} = 7.817371000127518 \bullet 10^{39} \bullet \sqrt[7]{\alpha_0^{130}}. \tag{3.10}$$

Here the following inequality is fulfilled:

$$\{\Phi < |\bar{c}(\psi_0)| < +\infty\},$$

because, by hypothesis, the experiment should be conducted for the *Light Ages* of the Universe $(2 < \psi < +\infty)$, when our Universe begun to be illuminated by stars.

3). From the formulas (3.9) and (3.10) for the case $\bar{c}(\psi_0)$, we calculate the corresponding value of the *parameter of self-organization* ψ_0 by the formula:

$$\psi_0 = 0.5 \bullet \left[\log_{\Phi} \left(\frac{1 - \left|\bar{c}(\psi_0)\right|^2 \bullet \Phi^2}{1 - \left|\bar{c}(\psi_0)\right|^2 \bullet \Phi^{-2}} \right) \right] \tag{3.11}$$

The value $\psi_0 > 2$, because the *Light Ages,* for which the *supporting experiment* should be carried out, according to the mathematical model of the *Fibonacci special theory of relativity*, corresponds to the range { $2 < \psi < +\infty$ }.

4). For the cases $T_0 > 0$ and $\psi_0 > 2$, we calculate the unknown value of the *weighting factor* λ_0 by the formula:

$$\lambda_0 = \frac{\psi_0}{T_0} \left[\frac{1}{billion\ years} \right] \tag{3.12}$$

3.10. Temporary restrictions of the different periods of the Universe existence following from the supporting experiment

From the formula (3.12) for any value of T in the range $-\infty < T < +\infty$, we get corresponding to the value of self-organization parameter ψ by the formula:

$$\psi = \lambda_0 \bullet T \text{ (dimensionless)} \tag{3.13}$$

Conversely, for any value of the parameter of self-organization $-\infty < \psi < +\infty$, we get the corresponding value of the time $-\infty < T < +\infty$ by the formula:

$$T = \frac{1}{\lambda_0} \bullet \psi \quad [billion\ years]. \tag{3.14}$$

Hence, for the *Fibonacci special theory of relativity*, we get the following time intervals T [*billion years*] for the different periods of the Universe existence:

1) For the *Light Ages* {$2 < \psi < +\infty$ } we get: $\left\{ \frac{2}{\lambda_0} < T < +\infty \right\}$.

2) For the *Dark Ages* {$0 < \psi < 2$ } we get: $\left\{ 0 < T < \frac{2}{\lambda_0} \right\}$.

3) For the *Black Hole* { $-\infty < \psi < 0$ } we get: { $-\infty < T < 0$ }.

4) For the *bifurcation point* $\psi = 0$ (*Big Bang* as the transition from the *Dark Ages* to the *Black Hole*) we get: $T = 0$.
5) For the *bifurcation point* $\psi = 2$ (the transition from the *Dark Ages* to the *Light Ages*) we get: $T = \frac{2}{\lambda_0}$.

3.11. A quantitative description of the Universe time evolution based on the supporting experiment

We recall the basic formulas, which describe the evolution of the Universe based on the *Fibonacci special theory of relativity*, depending on the *parameter of self-organization* ψ, $\{-\infty < \psi < +\infty\}$. These formulas look as follows:

$$\begin{cases} \bar{c}(\psi) = \sqrt{\dfrac{sF(\psi)}{sF(\psi-2)}}, c(\psi) = c_0 \bullet \bar{c}(\psi)\left[\dfrac{m}{\sec}\right], \bar{v}(\psi) = \dfrac{|\psi|}{\psi} \bullet \dfrac{\sqrt{[cF(\psi-1)]-1}}{cF(\psi-1)}, \\ v(\psi) = c_0 \bullet \dfrac{sF(\psi)}{cF(\psi-1)}\left[\dfrac{m}{\sec}\right], \alpha(\psi) = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times |c(\psi)|^{\frac{7}{130}}, c_0 = \dfrac{c^*}{\Phi} \approx 1.85281990 \bullet 10^8 \left[\dfrac{m}{\sec}\right] \end{cases} \quad (3.15)$$

The following procedure is a *quantitative description of the Universe time evolution* on the basis of the *supporting experiment*:

1). For the *Light Ages* we carry out the *supporting experiment* $(T_0 > 0, \alpha_0 > 0)$.

2). We calculate the positive *supporting numerical coefficient* by the formula $\lambda_0 = \frac{\psi_0}{T_0}\left[\frac{1}{billion\ years}\right]$.

3). We postulate that for any T in the range $\{-\infty < T < +\infty\}$ the following relation is valid: $\psi = \lambda_0 \bullet T$.

4). For any T in the range $\{-\infty < T < +\infty\}$, the values $\psi = \lambda_0 \bullet T$ are substituted into the relation (3.15), as the result we get for the *Fibonacci special theory of relativity* the following formulas, which give not only the complete *qualitative,* but also *quantitative* information on the Universe evolution:

$$\begin{cases} \bar{c}(\psi) = \sqrt{\dfrac{sF(\lambda_0 T)}{sF(\lambda_0 T-2)}},\ c(T) = c_0 \bullet \bar{c}(T)\left[\dfrac{m}{\sec}\right],\ \bar{v}(T) = \dfrac{|T|}{T} \bullet \dfrac{\sqrt{[cF(\lambda_0 T-1)]-1}}{cF(\lambda_0 T-1)}, \\ v(T) = c_0 \bullet \dfrac{sF(\lambda_0 T)}{cF(\lambda_0 T-1)}\left[\dfrac{m}{\sec}\right],\ \alpha(T) = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times |c(T)|^{\frac{7}{130}}, \\ c_0 = \dfrac{c^*}{\Phi} \approx 1.85281990 \bullet 10^8 \left[\dfrac{m}{\sec}\right] \end{cases} \quad (3.16)$$

3.12. Limit values of the fine-structure constant for the *Light Ages*, the *Dark Ages*, and the *Black Hole*

It follows from the formulas (3.12) and (3.13) that even in the absence of the supporting experiments for the *Light Ages* $\{2 < \psi < +\infty\}$ and the *Black Hole* $\{-\infty < \psi < 0\}$ we have the following limit relations, respectively:

$$\lim_{T\to+\infty} \bar{c}(\psi(T)) = \lim_{\psi\to+\infty} \bar{c}(\psi) = \Phi, \quad \lim_{T\to-\infty} \bar{c}(\psi(T)) = \lim_{\psi\to-\infty} \bar{c}(\psi) = \Phi^{-1}. \quad (3.17)$$

These arguments lead us to the following conclusions:

1). For the *Light Ages* $\{2 < \psi < +\infty\}$ (the *positive arrow* of time), the function $\bar{c}(\psi = |\bar{c}(\psi)| = \sqrt{\dfrac{sF(\psi)}{sF(\psi-2)}}$ at changing of ψ from 2 to $+\infty$ decreases *monotonically* from $\bar{c}(\psi = 2) = +\infty$ to $\bar{c}(\psi = +\infty) = \Phi$ .Consequently, the number of $\bar{c}(+\infty) = \Phi$ is the *lower bound* of the $\bar{c}(\psi)$ in the range $\{2 < \psi < +\infty\}$.

But then, according to (3.9), the *fine-structure constant* $\alpha(\psi) = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times |\bar{c}(\psi)|^{\frac{7}{130}}$ at changing of ψ from 2 to $+\infty$ decreases *monotonically* from the value

$$\alpha(\psi = 2) = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times |\bar{c}(\psi = 2)|^{\frac{7}{130}} = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times |(+\infty)|^{\frac{7}{130}} = +\infty$$

to the value

$$\alpha(\psi = +\infty) = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times |\bar{c}(\psi = +\infty)|^{\frac{7}{130}} = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times \Phi^{\frac{7}{130}} = 0.007297351997377362$$

Consequently, the lower bound of the *fine-structure constant* $\alpha(\psi)$ for the *Light Ages* is the number:

$$\alpha(\psi=+\infty)=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\Phi^{\frac{7}{130}}=0.0072973519973777362\,, \qquad (3.18)$$

what corresponds to *Kosinov's formula* (3.5).

Due to the limit relations (3.17), the *lower bound* of the *fine-structure constant* $\alpha(T)$ for the *Light Ages*, even for the absence of the supporting experiment, is equal to the number:

$$\alpha(T=+\infty)=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\Phi^{\frac{7}{130}}=0.0072973519973777362 \qquad (3.19)$$

2). For the *Black Hole* $\{-\infty<\psi<0\}$ at changing of ψ from 0 to $-\infty$ (the *negative arrow of time*), the function $\bar{c}(\psi)=\left|\bar{c}(\psi)\right|=\sqrt{\dfrac{sF(\psi)}{sF(\psi-2)}}$ *increases monotonically* from $\bar{c}(\psi=0)=0$ to $\bar{c}(\psi=-\infty)=\Phi^{-1}$

Consequently, the function $\bar{c}(\psi)$ is (strictly) decreasing on the interval $(-\infty,0)$ from the value Φ^{-1} to the value 0.

But then, according to $\bar{c}(\psi)=\left|\bar{c}(\psi)\right|=\sqrt{\dfrac{sF(\psi)}{sF(\psi-2)}}$, the *fine-structure constant* (3.9) at changing of ψ from 0 to $-\infty$ *increases monotonically* from the value

$$\alpha(\psi=0)=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\left|\bar{c}\left(\psi=0\right)\right|^{\frac{7}{130}}=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\left|0\right|^{\frac{7}{130}}=0$$

to the value

$$\alpha(\psi=-\infty)=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\left|\bar{c}\left(\psi=-\infty\right)\right|^{\frac{7}{130}}=$$

$$10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\left(\Phi^{-1}\right)^{\frac{7}{130}}=0.006928814497134813 5...$$

Due to the limit relations (3.17), the *upper bound* of the *fine-structure constant* $\alpha(T)$ for the *Black Hole*, even without the **supporting** experiment, at changing of T from 0 to $-\infty$, is the number:

$$\alpha(T=-\infty)=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\left(\Phi^{-1}\right)^{\frac{7}{130}}=0.0069288144971348135... \qquad (3.20)$$

3). For the *Dark Ages* { $0<\psi<2$ }, the *normalized Fibonacci velocity of light* in vacuum $\bar{c}(\psi)=i\bullet\left|\bar{c}(\psi)\right|$, that is, $\bar{c}(\psi)$ is *imaginary quantity***.** In order to find the values of the *fine-structure constant*, we use the formula (3.9):

$$\alpha=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\left|\bar{c}(\psi)\right|^{\frac{7}{130}},$$

where instead $\bar{c}(\psi)$ we take the module $\left|\bar{c}(\psi)\right|$, then at the interval { $0<\psi<2$ } the *fine structure constant* $\alpha=\alpha(\psi)$ takes the *real values*. The limit values for $\alpha(\psi)$ are the following:

$$\alpha(\psi=0)=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\left|\bar{c}(\psi)=0\right|^{\frac{7}{130}}=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times0^{\frac{7}{130}}=0,$$

$$\alpha(\psi=2)=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\left|\bar{c}(\psi)=2\right|^{\frac{7}{130}}=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times(+\infty)^{\frac{7}{130}}=+\infty,$$

The *fine-structure constant* $\alpha(\psi)$ at the interval { $0<\psi<2$ } at increasing of ψ is a *monotonically increasing function* from the value $\alpha(\psi=0)=0$ to $\alpha(\psi=2)=+\infty$. With regard to the limits of the *fine-structure constant* α for the *Dark Ages,* starting since the moment of the *Big Bang,* for which *T*=0, then the first limit value for *T*=0 does not depend on the *supporting experiment* ($(T_0>0,\alpha_0>0)$ and is equal to $\alpha(T=0)=0$

As for the other limit value $\alpha(\psi=2)=+\infty$, then the value of the time $T^*=T(\psi=2)$ depends on the reliability of the *supporting experiment*. As the *supporting experiment* should be carried out for the *Light Ages* and by this experiment, the values $(T_0>0,\alpha_0>0)$ are determined**,** then from here the *positive supporting numerical coefficient* is given definitely by the formula: $\lambda_0=\dfrac{\psi_0}{T_0}>0.$

Next, we use the relation $\psi=\lambda_0\bullet T$ for any values of ψ and *T*. From here, we get the formula $T=\dfrac{\psi}{\lambda_0}$ (see the formula (3.14)). But then the interval { $0<\psi<2$ } for the *Dark Ages* in terms of the time *T* [*billion years*] is given by $\left\{0<T<\dfrac{2}{\lambda_0}\right\}$, that is, it depends from the *supporting experiment*. For the endpoints $\psi=0, \psi=2$, which are *bifurcation points,* we get $T(\psi=0)$=0 [*billion years*] and $T(\psi=2)=\frac{2}{\lambda_0}$ [*billion years*], respectively.

3.13. Graphs, tables, and calculations

3.13.1. Graphs . The usage to this methodology for a quantitative description of the evolution of the universe for the model of the *Fibonacci special theory of relativity* on the basis of the given *supporting experiment* (T_0, α_0), realized for the *Light Ages* { 2< $\psi<+\infty$ }, is based on the fact that when we change the *parameter of self-organization* ψ from 2 to $+\infty$, the derivative $\frac{d\alpha(\psi)}{d\psi}$<0 . Note also that for the *Black Hole* {2< $\psi<+\infty$ } the derivative $\frac{d\alpha(\psi)}{d\psi}$<0. For the *Dark Ages* the derivative $\frac{d\alpha(\psi)}{d\psi}$>0.

The derivation of the derivative $\frac{d\alpha}{d\psi}$

Let us prove that the derivative $\frac{d\alpha}{d\psi}<0$ for the function $\alpha(\psi)=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\left|\bar{c}(\psi)\right|^{\frac{7}{130}}$, where $\left|\bar{c}(\psi)\right|=\sqrt{\frac{sF(\psi)}{sF(\psi-2)}}$, if $\{-\infty<\psi<0\}\cup\{2<\psi<+\infty\}$, and that the derivative $\frac{d\alpha}{d\psi}>0$ for the function $\left|\bar{c}(\psi)\right|=\sqrt{\frac{sF(\psi)}{sF(2-\psi)}}$, if $\{0<\psi<2\}$.

The derivative $\frac{d\alpha}{d\psi}$ for the interval $\{2<\psi<+\infty\}$ is calculated as follows. Let us introduce the following designations:

$$\kappa=10^{-\frac{43}{20}}\bullet\pi^{\frac{1}{260}};\ \Phi=\frac{1+\sqrt{5}}{2};\ \alpha=k\bullet\left|\bar{c}(\psi)\right|^{\frac{7}{130}};\ \left|\bar{c}(\psi)\right|=\sqrt{\frac{\Phi^{\psi}-\Phi^{-\psi}}{\Phi^{\psi-2}-\Phi^{2-\psi}}}$$

Then we have:

$$\frac{d\alpha}{d\psi}=\frac{7k\bullet\ln\Phi\left[-\frac{\left(\Phi^{\psi}-\Phi^{-\psi}\right)\bullet\left(\Phi^{\psi-2}+\Phi^{2-\psi}\right)}{\left(\Phi^{\psi-2}-\Phi^{2-\psi}\right)^{2}}+\frac{\Phi^{\psi}+\Phi^{-\psi}}{\Phi^{\psi-2}-\Phi^{2-\psi}}\right]}{260\left(\frac{\Phi^{\psi}-\Phi^{-\psi}}{\Phi^{\psi-2}-\Phi^{2-\psi}}\right)^{\frac{253}{260}}}$$

The sign of the derivative $\frac{d\alpha}{d\psi}$ coincides with the sign of the following expression:

$$(\Phi^{-\psi}-\Phi^{\psi})\bullet(\Phi^{\psi-2}+\Phi^{2-\psi})+(\Phi^{-\psi}+\Phi^{\psi})\bullet(\Phi^{\psi-2}-\Phi^{2-\psi})=-2\bullet(\Phi^{2}-\Phi^{-2})<0.$$

That is, in this case, the sign $\frac{d\alpha}{d\psi}$=-1. Similarly the derivative $\frac{d\alpha}{d\psi}<0$ is calculated for the interval $\{-\infty<\psi<0\}$ and the derivative $\frac{d\alpha}{d\psi}>0$ is calculated for the interval $\{0<\psi<2\}$.

The points $\psi=0,\psi=2$ are points of *bifurcation*. In the bifurcation points $\psi=0,\psi=2$, the derivative $\frac{d\alpha}{d\psi}$ is not defined and it is necessary to define it on the left and on the right of the bifurcation points.

To illustrate the above statements, we confine ourselves to the graph of the function (3.9) $\alpha(\psi)=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\left|\bar{c}(\psi)\right|^{\frac{7}{130}}$ on an infinite interval $\{-\infty<\psi<\infty\}$ (see Fig.3.1).

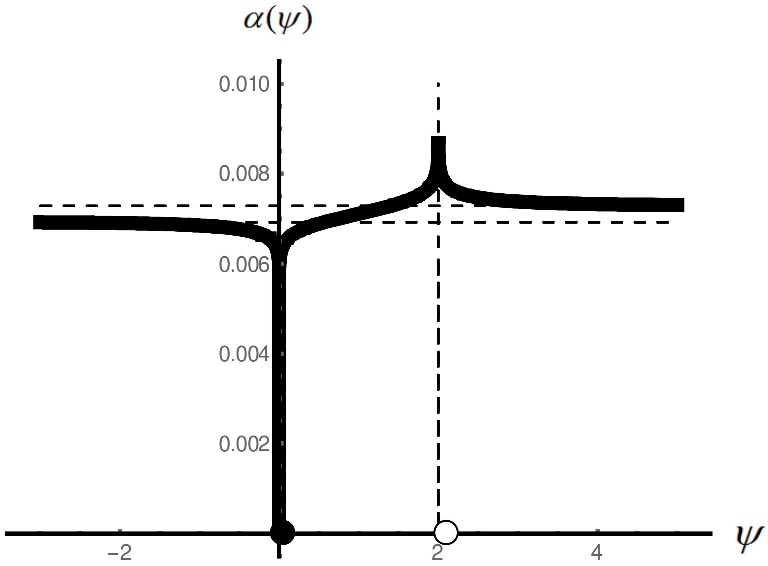

Figure 3.1. *The graph of the fine-structure constant (black curve) at* $\{-\infty < \psi < \infty\}$

For the *quantitative* description of the Universe evolution by using the model of the *Fibonacci special theory of relativity* on the basis of the given *supporting experiment* (T_0, α_0), we also need to find the explicit dependence of the *parameter of self-organization* ψ for the given values of the module $|\bar{c}(\psi)|$ of the *normalized Fibonacci light speed in vacuum* $\bar{c}(\psi)$. The *normalized Fibonacci light speed in vacuum* has the form:

$\bar{c}(\psi) = |\bar{c}(\psi)|$ at $\{-\infty < \psi < 0\} \cup \{2 < \psi < +\infty\}$ and $\bar{c}(\psi) = i \bullet |\bar{c}(\psi)|$ at $\{0 < \psi < 2\}$.

As $\bar{c}(\psi) = \sqrt{\dfrac{\Phi^{\psi} - \Phi^{-\psi}}{\Phi^{\psi-2} - \Phi^{-(\psi-2)}}}$, then $\left[\bar{c}(\psi)\right]^2 = \sigma \bullet \dfrac{\Phi^{\psi} - \Phi^{-\psi}}{\Phi^{\psi-2} - \Phi^{-(\psi-2)}}$, where $\sigma = 1$ at $\{-\infty < \psi < 0\} \cup \{2 < \psi < +\infty\}$ and $\sigma = -1$ at $\{0 < \psi < 2\}$. Hence we obtain the formula of dependence ψ from $\bar{c}(\psi)$, which has the following form:

$$\psi = 0.5\left[\log_{\Phi}\left(\frac{\sigma - |\bar{c}(\psi)|^2 \bullet \Phi^2}{\sigma - |\bar{c}(\psi)|^2 \bullet \Phi^{-2}}\right)\right], \qquad (3.21)$$

where $\log_{\Phi}(x)$ is the logarithm with the base Φ from the variable *x*. Recall that $\log_{\Phi}(x) = \dfrac{\ln(x)}{\ln(\Phi)}$.

Fig. 3.2 shows the graph of the formula (3.21) for any values $\{ -\infty < \psi < +\infty \}$.

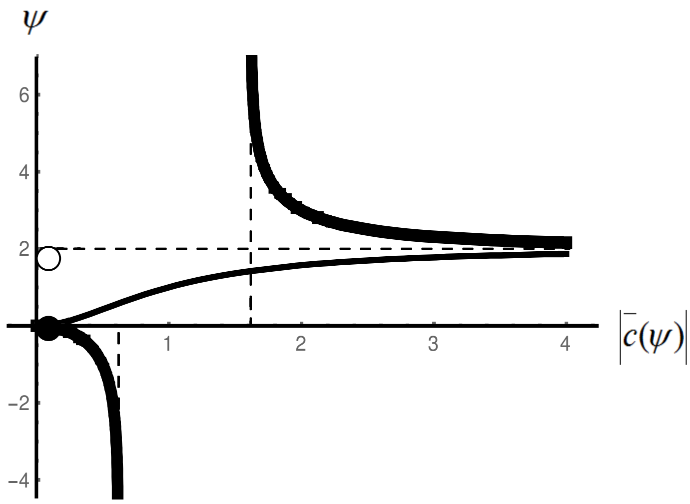

*Figure.*3.2. *The graph of the dependence of the parameter of self-organization* ψ *from the module* $|\bar{c}(\psi)|$ *of the normalized Fibonacci light velocity in vacuum* $\bar{c}(\psi)$.

The *wide black curve* in the upper part of Fig.3.2 corresponds to the *Light Ages*, for which

$$\{ \Phi < |\bar{c}(\psi)| < +\infty \} \Leftrightarrow \{ 2 < \psi < +\infty \}, \sigma = 1.$$

The *thin black curve* in the upper part of Fig. 3.2 corresponds to the *Dark Ages*,

for which $\{0 < |\bar{c}(\psi)| < +\infty\} \Leftrightarrow \{ 0 < \psi < 2\},\ \sigma = -1$

The *wide black curve* in the lower part of Fig. 3.2 corresponds to the *Black Hole*, for which

$$\left\{0 < |\bar{c}(\psi)| < \Phi^{-1}\right\} \Leftrightarrow \{ -\infty < \psi < 0\}, \sigma = 1.$$

3.13.2. Tables

<u>**The Black Hole**</u> $\{ -\infty < \psi < 0 \}$

Formulas for numerical calculations

$$\alpha(\psi) = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times |\bar{c}(\psi)|^{\frac{7}{130}},\ \bar{c}(\psi) = |\bar{c}(\psi)|,$$

$$\left|\bar{c}(\psi)\right| = \sqrt{\frac{\Phi^{\psi} - \Phi^{-\psi}}{\Phi^{\psi-2} - \Phi^{-(\psi-2)}}} = \mathrm{Exp}[\frac{130}{7} \bullet \ln(\alpha) + \frac{559}{14}\ln(10) - \frac{1}{14}\ln\ (\pi)],$$

$$\psi = 0.5\left[\log_{\Phi}\left(\frac{1 - \left|\bar{c}(\psi)\right|^{2} \bullet \Phi^{2}}{1 - \left|\bar{c}(\psi)\right|^{2} \bullet \Phi^{-2}}\right)\right],$$

where through Exp (x) the function e^{x} is denoted.

Table 3.1. The dependence of α from ψ for the *Black Hole*

ψ	α		ψ	α
$-\infty$	0.0069288144971348135		-4	0.00692538187440185
-10000	0.0069288144971348135		-3	0.006919646794970036
-1000	0.006928814497134813		-2	0.006903455705682327
-100	0.006928814497134813		-1	0.006850192996684811
-10	0.006928803964023771		-0.5	0.006768784213889069
-9	0.006928786919435824		-0.05	0.006406984558898941
-8	0.006928742286426307		-0.005	0.006026519400304021
-7	0.006928625369162896		-0.0005	0.005664706511828369
-6	0.006928318818909652		-0.00005	0.0053242413463155105
-5	0.0069275131121957064		0	0

Table 3.2. The dependence of ψ from $\left|\bar{c}(\psi)\right|$ for the *Black Hole*

$\left\|\bar{c}(\psi)\right\|$	ψ		$\left\|\bar{c}(\psi)\right\|$	ψ
0.618033988749895= Φ^{-1}	$-\infty$		0.6123724356957945	-4
0.618033988749894827	-10000		0.6030226891555273	-3
0.6180339887498948	-1000		0.5773502691896257	-2
0.6180339887498948	-100		0.5	-1
0.6180165405913052	-10		0.40044657145607854	-0.5
0.617988307121335	-9		0.14437305931408442	-0.05
0.6179143806533247	-8		0.04631539686890963	-0.005
0.6177207681213422	-7		0.014667481696040147	-0.0005
0.6172133998483676	-6		0.0046389387118200036	-0.00005
0.6158817620514397	-5		0	0

<u>The Dark Ages</u> { $0 < \psi < 2$ }

Formulas for numerical calculations

$$\alpha = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times \left|\bar{c}(\psi)\right|^{\frac{7}{130}}, \quad \bar{c}(\psi) = i \bullet \left|\bar{c}(\psi)\right|,$$

$$\left|\bar{c}(\psi)\right| = \sqrt{\frac{\Phi^{\psi} - \Phi^{-\psi}}{\Phi^{\psi-2} - \Phi^{-(\psi-2)}}} = \mathrm{Exp}[\frac{130}{7} \bullet \ln(\alpha) + \frac{559}{14}\ln(10) - \frac{1}{14}\ln(\pi)],$$

$$\psi = 0.5\left[\log_{\Phi}\left(\frac{1+\left|\bar{c}(\psi)\right|^{2} \bullet \Phi^{2}}{1+\left|\bar{c}(\psi)\right|^{2} \bullet \Phi^{-2}}\right)\right]$$

Table 3.3. The dependence of α from ψ for the *Dark Ages*

ψ	α		ψ	α
0	0		1.15	0.007173203111587392
0.00000005	0.004420677984437741		1.295	0.007236786535409398
0.0000005	0.004703400500624787		1.3995	0.007286414039484436
0.000005	0.0050042047632669956		1.49995	0.007339081525719611
0.00005	0.005324250600866376		1.599995	0.007399158790659007
0.0005	0.005664804976045141		1.6999995	0.007471875746442799
0.005	0.006027567016514314		1.79999995	0.007568544855416565
0.05	0.006418132522321802		1.899999995	0.007725409677896242
0.5	0.006889391594589547		1.9999999995	0.012947368238045895
1	0.007110696049622987		2	+∞

Table 3.4. The dependence of ψ from $\left|\bar{c}(\psi)\right|$ for the *Dark Ages*

$\left\|\bar{c}(\psi)\right\|$	ψ		$\left\|\bar{c}(\psi)\right\|$	ψ
0	0		1.176495436910126	1.15
0.00014669849260547704	0.00000005		1.3860143882604832	1.295
0.000463901433387913	0.0000005		1.5735816664444588	1.3995
0.001466987270482024	0.000005		1.798780757504753	1.49995
0.004639088462289398	0.00005		2.0928249016653453	1.599995
0.014672217221849427	0.0005		2.5096386981179037	1.6999995
0.04646514788007947	0.005		3.186330402711177	1.79999995
0.14911029919188895	0.05		4.663866193655711	1.899999995
0.5558929702514211	0.5		68167.01784975648	1.9999999995
1	1		+∞	2

<u>The Light Ages</u> $\{2 < \psi < +\infty\}$

Formulas for numerical calculations

$$\alpha = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times \left|\bar{c}(\psi)\right|^{\frac{7}{130}}, \quad \bar{c}(\psi) = \left|\bar{c}(\psi)\right|,$$

$$\left|\bar{c}(\psi)\right| = \sqrt{\frac{\Phi^{\psi} - \Phi^{-\psi}}{\Phi^{\psi-2} - \Phi^{-(\psi-2)}}} = \mathrm{Exp}[\frac{130}{7} \bullet \ln(\alpha) + \frac{559}{14}\ln(10) - \frac{1}{14}\ln(\pi)],$$

$$\psi = 0.5\left[\log_{\Phi}\left(\frac{1 - \left|\bar{c}(\psi)\right|^{2} \bullet \Phi^{2}}{1 - \left|\bar{c}(\psi)\right|^{2} \bullet \Phi^{-2}}\right)\right]$$

Table 3.5. The dependence of α from ψ for the *Light Ages*

ψ	α		ψ	α
2	$+\infty$		5	0.007307020113639036
2.0000005	0.01075009435860901		6	0.007300968990174425
2.000005	0.010103904514440983		7	0.0072987228593058675
2.00005	0.009496563927388494		8	0.0072978740776367965
2.0005	0.008925793102351615		9	0.007297551190335574
2.005	0.008389917123235882		10	0.007297428049702034
2.05	0.007891699729461058		100	0.007297351997377362
2.5	0.0074698788899746965		1000	0.007297351997377362
3	0.007381105661489203		10000	0.007297351997377362
4	0.007324157706770783		$+\infty$	0.007297351997377362

Table 3.6. The dependence of ψ from $\left|\bar{c}(\psi)\right|$ for the *Light Ages*

$\left\|\bar{c}(\psi)\right\|$	ψ		$\left\|\bar{c}(\psi)\right\|$	ψ
$+\infty$	2		1.6583123951777001	5
2155.6310252322273	2.0000005		1.632993161855452	6
681.6713738379511	2.000005		1.6236882817719775	7
215.56654703247312	2.00005		1.620185174601965	8
68.17802951613534	2.0005		1.618854426800759	9
21.59109211198998	2.005		1.618347187425374	10
6.926500032284402	2.05		1.618033988749895	100
2.4972120409568324	2.5		1.6180339887498953	1000
2	3		1.61803398874989	10000
1.7320508075688774	4		1.618033988749895= Φ	$+\infty$

Calculations

According to current data, the period of the *Dark Ages* { $0< \psi <2$} ended after 550 [*million years*] from the moment of the *Big Bang*, when the first stars, quasars, galaxies, clusters and super clusters of galaxies began to form. It was happened the re-ionization of hydrogen by the light of stars and quasars. For more detailed information we present the table of the *Chronology of the Big Bang*.

Table 3.7. Chronology of the Big Bang

Time T from the moment of the Big Bang	**Age**	**Event**	**To the present moment, billion years**
0	**Singularity**	**Big Bang**	**13,7 billion years**
0 — 10^{-43} c	**Beginning Dark Ages.** Planck epoch	Birth of particles	13,7 billion years
10^{-43} — 10^{-35} c	The era of Grand Unification	Separation of gravity from the united electroweak and strong interactions. Possible birth of monopoles. The destruction of the Grand Unification.	13,7 billion years
10^{-35} — 10^{-32} c	The inflationary epoch	The radius of the Universe increases exponentially on many orders. The structure of the primary quantum fluctuations by means of swelling gives the beginning of large-scale structure of the universe. Secondary heating Baryogenesis..	13,7 billion years
10^{-32} — 10^{-12} c	Electroweak epoch	The universe is filled with a quark-gluon plasm, leptons, photons, W- and Z-bosons, the Higgs boson. Breaking supersymmetry.	13,7 billion years
10^{-12} — 10^{-6} c	Quark era	Electroweak symmetry is broken, all four fundamental interactions exist separately. Quarks have not yet merged into hadrons. The universe is filled with a quark-gluon plasma, leptons and photons.	13,7 billion years
10^{-6} — 100 c	Hadron era	Hadronization. The annihilation of baryon-antibaryon pairs. Thanks CP-violation remains	13,7 billion years

		a small excess of baryons over antibaryons (about 1:10^9).	
100 seconds — 3 minutes	Lepton era	The annihilation of lepton-antileptons pairs. The collapse of the neutrons. The substance becomes transparent to neutrinos.	13,7 billion years
3 minutes — 380 000 years	Proton era	Nucleosynthesis of helium, deuterium, traces of lithium-7 (20 minutes). The substance starts to dominate over the radiation (70 000 s) that lead to changes in the expansion of the universe. At the end of the era (380 000 years) recombination of hydrogen and the universe becomes transparent to photons of thermal radiation.	13,7 billion years
380 000 years — **550 million years**	The *Dark Ages* **The end of the *Dark Ages***	The universe is filled with hydrogen and helium, the relict radiation of atomic hydrogen at 21 cm. The stars, quasars and other bright sources are absent.	13,15 billion years
550 million years — 1 billion years	**Beginning *Light Ages*. Reionization**	Forming the first stars (stars population III), quasars, galaxies, clusters and superclusters of galaxies. **Reionization** of hydrogen by the light of stars and quasars.	12,7 billion years
1 billion years — 8,9 billion years	The era of the substance	The formation of interstellar clouds, which gave rising the Solar System.	4.8 billion years
8,9 billion years— 9,1 billion years		The formation of the Earth and other planets of the Solar System, hardening breeds	4.6 billion years

Table 3.7 is created on the materials of Wikipedia, the free encyclopaedia https://ru.wikipedia.org/wiki / Chronology of the *Big Bang*

In this publication, for the *Fibonacci special theory of relativity* we will follow to the following strategy:

1). We leave the value of time T, measured from the *Big Bang* to the present time, the same as in Table 3.7, i.e. T=13.7 [*billion years*]. Until now there is no clear consensus on the value of the time T, because in addition to T=13.7 [*billion years*], the following options are offered: T=13.73, 13.75, 13.798, 13. 81 [*billion years*] and so on [21-29].

This once again confirms the opinion, expressed by David Hilbert in 1900 that in *experimental sciences there is not any completely precise data***.** They always have some uncertainty. In order to achieve the authentic harmony with reality, we need to create the rigorous mathematical model (according to Hilbert):

"It remains to discuss briefly what general requirements may be justly laid down for the solution of a mathematical problem. I should say first of all, this: that it shall be possible to establish the correctness of the solution by means of a finite number of steps based upon a finite number of hypotheses which are implied in the statement of the problem and which must always be exactly formulated. This requirement of logical deduction by means of a finite number of processes is simply the requirement of rigor in reasoning. Indeed the requirement of rigor, which has become proverbial in mathematics, corresponds to a universal philosophical necessity of our understanding; and, on the other hand, only by satisfying this requirement do the thought content and the suggestiveness of the problem attain their full effect"[1-3].

2). we use as the initial value of the *fine-structure constant* α the following value, given by Kosinov's formula [24]:

$$\alpha = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times |\Phi|^{\frac{7}{130}} = 0.0072973519973 77362 .$$

Since 2014, the recommended SODATA (http://www.codata.org) value of the fine-structure constant is as follows

$$\alpha = \frac{1}{137.035999139} = 7.2973525664 \times 10^{-3} \quad \text{(dimensionless).}$$

Thus, the absolute error $\Delta\alpha$ between the true and estimated values α is equal to:

$$\Delta\alpha = \left|7.2973525664 \times 10^{-3} - 7.2973519973 \times 10^{-3}\right| .$$
$$= 5.691 \times 10^{-10} = 0.0000000005691$$

The relative error $\frac{\Delta\alpha}{\alpha}$ in this case, equal to:

$$\frac{\Delta\alpha}{\alpha} = \frac{5.691 \times 10^{-10}}{7.2973525376 \times 10^{-3}} = 7.779872 \times 10^{-8} = 0.0000000779872 ,$$

that is, Kosinov's formula [24] actually coincides with the recommended CODATA value of the fine-structure constant.

Next, we will consider two examples of experiments and their *quantitative* comparison with numerical data, obtained by using the mathematical model of the *Fibonacci special theory of relativity.*

Mainly, this problem concerns to numerical comparisons of the *experimental* and *theoretical* results, related to the value of the time *T*, which is measured from the moment of the *Big Bang*, and also with modification of the *fine-structure constant*, depending on the time *T*.

We note that in the framework of the classical special theory of relativity, which postulates the *constancy of the light speed in a vacuum*, such a comparison is *impossible in principle.*

Example 1. Experiment for the bifurcation point ψ=2

For the observable Universe at $\psi_0 = 2$ (this bifurcation point corresponds to the transition from the *Dark Ages* to the *Light Ages*), the *fine-structure constant* $\alpha = +\infty$ (see Tables 3.3 and 3.5). Therefore, the *supporting experiment* in the case (T_0, α_0) is *impossible*.

However, it was determined **e**xperimentally (see Table 3.7), that for this case we have: $T_0 = 550[\text{million years}] = 0.55[\text{billion years}]$. But then we get the following values for the *supporting numerical coefficient* λ_0 and the *inverse supporting numerical coefficient* λ_0^{-1}:

$$\lambda_0 = \frac{\psi_0}{T_0} = \frac{2}{0.55} = 3.636363363\left[\frac{1}{\text{billion years}}\right], \quad \lambda_0^{-1} = 0.275[\text{billion years}] \quad (3.22)$$

Therefore, for any *T* [*billion years*] we get:

$$\psi = \lambda_0 \bullet T = \frac{2}{0.55} \bullet T \ [\text{dimensionless}], \quad (3.23)$$

and for any ψ we have:

$$T = \lambda_0^{-1} \bullet \psi = 0.275[\text{billion years}] \quad (3.24)$$

In particular, for *T*=13.7 [*billion years*] we get:

$$\psi = \lambda_0 \bullet T = \frac{2}{0.55} \bullet T = 3.63636 \bullet 13.7 = 49.8182 \quad (3.25)$$

$$\bar{c}(\psi) = \left|\bar{c}(\psi)\right| = \sqrt{\frac{\Phi^{\psi} - \Phi^{-\psi}}{\Phi^{\psi-2} - \Phi^{-(\psi-2)}}} = 1.618033988749895[\text{dimensionless}] \qquad (3.26)$$

$$\alpha = 10^{-\frac{43}{20}} \times \pi^{\frac{1}{260}} \times \left|\bar{c}(\psi)\right|^{\frac{7}{130}} = 0.00729735199737362\,[\text{dimensionless}] \qquad (3.27)$$

Example 2. As noted above, the quasars observations, made in April 2004 by using UVES spectrograph on one of the 8.2-meter telescope of Paranal Observatory in Chile, showed, that 10 billion years ago the possible value of α could not be more than 6×10^{-7} of α.

Because we assumed, that the current age of the Universe, measured from the moment of the *Big Bang*, is *T*=13.7[*billion years*], then 10 billion years ago, this age was equal to $T_0 = 13.7 - 10 = 3.7\left[\textit{billion years}\right]$.

For the modern time *T*=13.7[*billion years*] the *fine-structure constant* $\alpha = 0.0072973519973 77362$. Then, according to the Paranal Observatory in Chile for the past age of the Universe T_0=3.7 [*billion years*], the *fine-structure constant* α_0 satisfies to the non-equalities:

$$\begin{aligned} &\alpha_{\min} = 0.0072973519973 77362 < \alpha_0 \le \alpha_{\max} = 0.0072973519973 77362 + \Delta\alpha = \\ &= 0.00729735637885605, \end{aligned} \qquad (3.28)$$

where $\Delta\alpha = 6\bullet10^{-7}\bullet\alpha = 4.37841198426416\bullet10^{-9}$.

According to the data, obtained in **Example 1**,

$$\lambda_0 = \frac{\psi_0}{T_0} = 3.636363636363636363\left[\frac{1}{\textit{billion years}}\right].$$

This implies that the *parameter of self-organization* ψ_0, corresponding to the past age of the Universe T_0=3.7 [*billion years*] is equal to the value

$$\psi_0 = \lambda_0 T_0 = 3.636363636363636363 \bullet 3.7 = 13.454545454545455[\text{dimensionless}]. \qquad (3.29)$$

Because the resulting value $\psi_0 > 2$, then the given *supporting experiment* $\{T_0, \alpha_0\}$ held for the *Light Ages* { $2 < \psi < +\infty$ }. As mentioned above, for the *Fibonacci special theory of relativity for Light Ages* the following relation is valid:

$\bar{c}(\psi)=\left|\bar{c}(\psi)\right|=\sqrt{\dfrac{\Phi^{\psi}-\Phi^{-\psi}}{\Phi^{\psi-2}-\Phi^{-(\psi-2)}}}$, where $\bar{c}(\psi)$ is the *normalized Fibonacci light velocity in vacuum.*

By substituting $\psi_0=13.454545454545455$ into the formula for $\left|\bar{c}(\psi)\right|$, we get: $\left|\bar{c}(\psi_0)\right|=1.618045254395514$. By substituting this value $\left|\bar{c}(\psi_0)\right|$, into the formula $\alpha=10^{-\frac{43}{20}}\times\pi^{\frac{1}{260}}\times\left|\bar{c}(\psi)\right|^{\frac{7}{130}}$, we get: $\alpha_0=0.007297354733194072$.

From the above arguments we get the following non-equalities:

$$\begin{aligned}&\alpha_{\min}=0.007297351997377362<\alpha_0=0.007297354733194072<\\&<\alpha_{\max}=0.0072973563757885605\end{aligned}\tag{3.30}$$

From the non-equalities (3.30) we obtain the following deviations:

1) $\Delta\alpha_{\min}=\left|\alpha_{\min}-\alpha_0\right|=2.735816710328076\bullet10^{-9}$ is the *absolute deviation* of $\alpha_{\min}$ from α_0,

$\dfrac{\Delta\alpha_{\min}}{\alpha_{\min}}=3.7490540559251047\bullet10^{-7}$ is the *relative deviation* of $\alpha_{\min}$ from α_0.

2) $\Delta\alpha_{\max}=\left|\alpha_{\max}-\alpha_0\right|=4.378411198706356\bullet10^{-9}$ is the *absolute deviation* of $\alpha_{\max}$ from α_0, $\dfrac{\Delta\alpha_{\max}}{\alpha_{\max}}=6.000000000\bullet10^{-7}$ is the *relative deviation* of $\alpha_{\max}$ from α_0.

3.14. Reconciliation of the theoretical results of the Fibonacci special theory of l relativity with experimental data

1). Thus, we see that indeed the inequalities (3.30) are fulfilled:

$$\alpha_{\min}<\alpha_0\le\alpha_{\max}.$$

Moreover, the difference between the *experimental data* $\alpha_{\min},\alpha_{\max}$ (*«experience»*), obtained as a result of astronomical observations, and the *theoretical data* α_0 (“*thinking*"), obtained under the *Fibonacci special theory of relativity*, *manifested in the ninth decimal digit* after the point for the *absolute deviation* and in the *seventh decimal digit* after the point for the *relative deviation***.**

2). Consequently, the mathematical model of the *Fibonacci special theory of relativity* is *fully consistent* with the following *experimental data*:

a_1). Ending of the *Dark Ages* after the *Big Bang* happened through 550 million years (see Table 3.7).

a_2).10 billion years ago, the possible value of the *fine-structure constant* α could not be more than 0.6 million part (6×10^{-7}) of the α (observational data of Paranal Observatory in Chile）.

3.15. Quantitative results of the Fibonacci special theory of relativity from the moment of the Big Bang *T*=0 to any value of the time *T* [*billion years*]

3.15.1. The *Light Ages* (*T*>0.55 [*billion years*])

1). The *fine-structure constant* α [dimensionless] with *increasing* the time *T* *decreases* from $\alpha = +\infty$ to $\alpha = \dfrac{1}{137.03600982375468}$ =0.007297351997377362.

2). The *light speed in vacuum* $c\left[\dfrac{m}{\sec}\right]$ with *increasing* the time *T decreases* from $c = +\infty$ to c=2.99 792 458$\bullet 10^8$ (the *light speed in vacuum* for the *classical special theory of relativity*).

3). The *speed of the light source in vacuum* $v\left[\dfrac{m}{\sec}\right]$ with *increasing* the time *T* *increases* from $v = 0$ to v=2.99 792 458$\bullet 10^8$.

3.15.2. The *Dark Ages* (0<*T*< 0.55 [*billion years*])

1). The *fine-structure constant* α [dimensionless] with *increasing* the time *T* *increases* from $\alpha = 0$ to $\alpha = +\infty$

2). The *light speed in vacuum* $c\left[\dfrac{m}{\sec}\right]$ is *imaginary quantity*.

3). The *speed of the light source in vacuum* $v\left[\dfrac{m}{\sec}\right]$ is *imaginary quantity*.

3.15.3. The *Black Hole* (*T*< 0)

1). The *fine-structure constant* α [dimensionless] with *decreasing* the time *T* *increases* from

$$\alpha = 0 \text{ to } \alpha = \frac{1}{144.32483369464106} = 0.006928814497134813 5.$$

2). The *light speed in vacuum* $c\left[\frac{m}{\sec}\right]$ with *decreasing* the time *T increases* from c=0 to c= $1.1451052938512468 \bullet 10^8$.

3). The *speed of the light source in vacuum* $v\left[\frac{m}{\sec}\right]$with *decreasing* the time *T* **decreases** from v=0 **to** $v = -1.1451052938512468 \bullet 10^8$.

3.16. Advantages of the Fibonacci special theory of relativity in comparison with the classical special theory of relativity

The *Fibonacci special theory of relativity* has the following advantages over the *classical special theory of relativity*:

1). The *Fibonacci special theory of relativity* provides a *high consistency of the theoretical data with the latest experimental data***,** containing information on the *particular values* of the *fine-structure constant* α as the function of the time *T* since the moment of the *Big Bang*.

2). The *Fibonacci special theory of relativity* establishes the connection between the any values of the time *T* since the moment of the *Big Bang* and the following variables, which can be calculated according to this theory: the *fine structure constant* $\alpha = \alpha(T)$, the *light velocity in vacuum c=c* (*T*), the *velocity of the light source v= v* (*T*).

3). The *Fibonacci special theory of relativity* allows to get, in dependence of the value of *T*, the *qualitative* and *quantitative* (numerical) information about the following variables: the *fine-structure constant* $\alpha = \alpha(T)$, the *light velocity in vacuum c=c* (*T*), the *velocity of the light source v= v* (*T*) not only for the *Light Ages,* but also for the *Dark Ages* and the *Black Hole.* .

4). Einstein's postulate about the *constancy of the light speed in vacuum* is the main postulate of the *classical special theory of relativity.* In this connection, the *classical special theory of relativity* does not own with the possibilities of the *Fibonacci special theory of relativity*. According to the formulas of the *classical special theory of relativity* is fundamentally impossible to calculate the values of the *fine-structure constant*, depending on the different ages of the Universe since the moment of the *Big Bang.*

5). Knowledge of the dependence of the fine structure constant $\alpha = \alpha(T)$ from the Universe age T is one of the most mysterious physical-mathematical problem of modern science. Even the minor deviations, as the latest experiments show, dramatically can alter our ideas about the evolution of the Universe.

6). The authors in **Section 3** of this article showed, that the described in **Section 2** *Fibonacci special theory of relativity* it is a mathematical theory, that solves the problem of the *variability of the fine-structure constant* α depending on the different ages of the Universe since the *Big Bang*. This theory, developed on the basis of the Mathematics of Harmony [8] is highly consistent with modern experimental data and is a kind of the *genetic code of the Universe*. No wonder, the physical-mathematical problem of the *fine- structure constant* is named "MILLENNIUM PROBLEM."

7). The created by the authors *Fibonacci special theory of relativity* meets the basic requirements, which were presented in 1900 by David Hilbert to his unsolved (due to its vagueness) physical- mathematical Sixth Problem, which in fact is reduced to the question of the *harmony* between mathematical theory and physical experiment.

Hilbert writes [1-3]:

" *I should say first of all, this: that it shall be possible to establish the correctness of the solution by means of a finite number of steps based upon a finite number of hypotheses which are implied in the statement of the problem and which must always be exactly formulated. This requirement of logical deduction by means of a finite number of processes is simply the requirement of rigor in reasoning*"

Since physical experiments always have errors and therefore, according to Hilbert [1-3], *«in the meantime, while the creative power of pure reason is at work, the outer world again comes into play, forces upon us new questions from actual experience, opens up new branches of mathematics, and while we seek to conquer these new fields of knowledge for the realm of pure thought, we often find the answers to old unsolved problems and thus at the same time advance most successfully the old theories. And it seems to me that the numerous and surprising analogies and that apparently prearranged harmony which the mathematician so often perceives in the questions, methods and ideas of the various branches of his science, have their origin in this ever-recurring interplay between thought and experience»*.

Although Hilbert's Sixth Problem is called "*Mathematical statement of the axioms of physics*", but Hilbert recognizes that the creation of the system of axioms in physics that would meet properties of *consistency, independence* and *completeness*, is virtually impossible.

Therefore, a priori, as follows logically from Hilbert's above-cited words, the only one possibility remains to create the *mathematical theory of physical problem*, and then to *check its reliability by using finite number of experiments***.**

The created by the authors *Fibonacci special theory of relativity* (see Section 2 of this work, and References for it) fully meets this Hilbert requirement.

8). In conclusion, the authors put forward the task to create on the basis of the Mathematics of Harmony the analogue of the *classical Einstein's general theory of relativity*, which can be called the *Fibonacci general theory of relativity*. The solution to this problem is beyond the scope of this publication.

4. Conclusions

In 2000 a group of the eminent physicists has formulated the 10 Physics MILLENIUM PROBLEMS. These Physics MILLENIUM PROBLEMS have been presented at the *Strings 2000 Conference* (July, 10-15, University Michigan, Ann Arbor).

The first Physics MILLENIUM PROBLEM, formulated by the prominent physicist, David Gross (University of California, Santa Barbara), Nobel Prize Laureate in Physics-2004, sounds as follows:

"*Are all the (measurable) dimensionless parameters that characterize the physical universe calculable in principle or are some merely determined by historical or quantum mechanical accident and incalculable?"*

The authors of this article have focused on the *fine-structure constant (Sommerfeld's constant)*, which is a fundamental dimensionless physical constant, characterizing the strength of the electromagnetic interaction between elementary charged particles.

Bearing in mind the *fine-structure constant* as the main dimensionless physical constants of physical world, the authors of the present article have reformulated David Gross' MILLENNIUM PROBLEM as follows:

"Is the fine-structure constant, which characterizes the physical universe, calculable or non calculable?"

Based on *Mathematics of Harmony* [8], the *"golden" matrices* [9] and *Fibonacci special theory of relativity* [7,12,13,17,18], the authors of this article have deduced the mathematical formula that determines the dependence of the *fine-structure constant* from the time *T* since the *Big Bang*.

This formula makes it possible to calculate the values of the *fine-structure constant* for all stages of evolution of the Universe starting since the *Big Bang* (the *Dark Ages*, the *Light Ages*) and the *Black Hole* (the negative arrow of time).

We have proved the high coincidence of theoretical data for the value of the fine structure constant α with the experimental data for the *Light Ages* of the Universe (see also Fig. 3.1 and Tables 3.5-3.6).

A substantiation of the coincidence between the theoretical and experimental data for the *Black Hole* and the *Dark Ages* is not possible. Such experimental data in physics and astronomy do not exist yet. However, we have pointed out both theoretical and numerical picture of the change of the fine-structure constant for the *Black Hole*, and for the *Dark Ages* (Fig. 3.1, Tables 3.1-3.2, 3.3-34).

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