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Information Estimate of the Mass of Universe's Initial Heterogeneity

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Abstract

The report includes the following questions: Definitions of homogeneity and heterogeneity. Heterogeneity stable for definite time. The estimate occurrence of heterogeneity defined by the information divergence of the distribution of heterogeneity against uniform distribution. The estimate of information volume in Planck's particle. Initially there were heterogeneities of usual matter and of dark matter in the Universe. Initially and then there were no heterogeneities of dark energy. Estimate of the mass of the initial heterogeneities. Growth of heterogeneities in the expanding Universe.

Keywords: Universe, information, matter, energy, informatics laws, homogeneity, heterogeneity, initial, Planck's particle.

Introduction

Were there any heterogeneities in the Universe [1-3] at the beginning of its existence? Or heterogeneities formed later, during the expansion of the Universe's.

"Let us emphasize at once that some initial heterogeneities of the Universe are necessary as against the totally Universe the formation of large-scale structure (galaxies, their clusters) is not possible" [2 pp. 12-13]

"Some fourteen billion years ago, at the moment of birth Universe entire was confined at the radius of 10^{-33}cm, which is far less that the radius of proton- 10^{-13}cm. In that volume all the information about the future of the Universe was contained. The Big Bang took place" (We will name the given statement as a hypothesis about the initial information [4]).

To investigate the existence and characteristics of the Universe's initial heterogeneities the information approach is applicable using information entropy by Shannon [5] as a measure of heterogeneity. We shall evaluate the very existence of heterogeneity by information divergence [6-11].

Definitions and Designations

Let us bring forward necessary definitions. By the author's definition information –is heterogeneity that is stable for a certain time [6, стр. 35]. "We shall understand by information the stable for some definite time heterogeneities of arbitrary physical nature". Therefore a letter in a book, an atom, a molecule, an elementary particle, a star, a drawing, a picture, a ploughed land, a forest and other heterogeneities contain and carry information."

The quoted definition of information is based on the following concepts:

- Heterogeneity.
- Stable heterogeneity.
- Heterogeneity stable for definite time.

Let us give definitions of homogeneity and heterogeneity

Heterogeneity

Let us analyze a set *M*, consisting of elements *m*. If the elements *m* are equal, identical (do not differ from each other), then the set *M* is homogeneous.

If there are not identify elements among the elements *m* (non-identical, different from each other) then the set *M* is heterogeneities. By the set as usually "one name for the sum total of all the objects, possessing given quality is understood" (Georg Kantor).

These objects are called by elements of a set.

Stability of heterogeneity – conservation of heterogeneity, its structure, characteristics.

Time of stability of heterogeneity – time of heterogeneity's existence (life), time of heterogeneity's conservation, its structure, characteristics.

"Information is fortuitous and remembered choice of one variant out of several possible and equivalent variants. The word "fortuitous" here is selected as it belongs to the process (way) of choice and therefore limits the range of the definition's application. In general the choice may be also not fortuitous (suggested), in this case they say about reception of information. Fortuitous choice corresponds to generating (that is spontaneous inception) of information. In general terms the choice may be not remembered (that is be forgotten at once). We shall call such choice microinformation. We shall call remembered choice by the macroinformation (contrary to not remembered). In all informational processes macroinformation (remembered) is used". We shall identify classic information with macroinformation of D.C. Chernavsky [12].

Let fortuitous value x is described by the function (density) of distribution $P(x)$.

The difference of fortuitous value described by the function (density) of distribution $P(x)$ from the fortuitous value described by the function (density) of distribution $Q(x)$ is estimated by informational divergence $D(P/Q)$ of distribution P against distribution Q [13-14]

$$D(P/Q) = -\int P(x) \cdot \log_2 \frac{P(x)}{Q(x)} \cdot dx =$$
$$-\int P(x) \cdot \log_2 P(x) \cdot dx + \int P(x) \cdot \log_2 Q(x) \cdot dx .$$

We shall estimate occurrence of heterogeneity defined by the distribution P by the information divergence $D(P/R)$ of the distribution P against uniform distribution R.

$$D(P/R) = -\int P(x) \cdot \log_2 \frac{P(x)}{R(x)} \cdot dx = -\int P(x) \cdot \log_2 P(x) \cdot dx + \int P(x) \cdot \log_2 R(x) \cdot dx$$

$P(x) \cdot$ **-** is distribution characterizing required heterogeneity of the Universe in a certain instant of time.

$R(x) \cdot$ uniform distribution at the interval $0 \le x \le a$

$$R(x) = \begin{cases} 0 & \text{if } -\infty < x \le 0 \\ \frac{1}{a} & \text{if } 0 < x \le a \\ 0 & \text{if } a < x \le \infty \end{cases} .$$

If $R(x)$ is uniform distribution at the interval $0 \le x \le a$ and $P(x)$ is also defined at the interval $0 \le x \le a$ then information divergence is equal to

$$D = -\int_0^a P(x) \cdot \log_2 \frac{P(x)}{\frac{1}{a}} \cdot dx = -\int_0^a P(x) \cdot \log_2 (a \cdot P(x)) \cdot dx .$$

In the same way heterogeneity is estimated by information divergence in multidimensional case.

Occurrence of heterogeneity set by the distribution P is estimated by information divergence $D(P/R)$ of the distribution P against uniform distribution R

$$D(P/R) = -\int P(x)\cdot\log_2 \frac{P(x)}{R(x)}\cdot dx = -\int P(x)\cdot\log_2 P(x)\cdot dx + \int P(x)\cdot\log_2 R(x)\cdot dx$$

$P(x)\cdot$ ($x = x_1, x_2, x_3$) - is distribution characterizing required heterogeneity in a certain instant of time.

$R(x)$ ($x = x_1, x_2, x_3$)- is uniform distribution in the volume V

$$R(x) = \begin{Bmatrix} \frac{1}{V} \text{ при } & x \in \mathrm{V} \\ 0 \text{ при } x \notin V \end{Bmatrix}$$

If $R(x)$ ($x = x_1, x_2, x_3$) is uniform distribution in the volume V and $P(x)$ is also defined in the volume V, then informational divergence is equal to

$$D = -\int\limits_{\mathrm{V}} P(x)\cdot\log_2 \frac{P(x)}{\frac{1}{\mathrm{V}}}\cdot dx = -\int\limits_{V} P(x)\cdot\log_2 (V\cdot P(x))\cdot dx\,.$$

We have in particular

$$D(P/R) = -\int P(x_1,x_2,x_3)\cdot\log_2 \frac{P(x_1,x_2,x_3)}{R(x_1,x_2,x_3)}\cdot dx_1 dx_2 dx_3 =$$

$$-\int P(x_1,x_2,x_3)\cdot\log_2 P(x_1,x_2,x_3)\cdot dx_1 dx_2 dx_3 + \int P(x_1,x_2,x_3)\cdot\log_2 R(x_1,x_2,x_3)\cdot dx_1 dx_2 dx_3$$

.

$P(x_1, x_2, x_3)$ - distribution characterizing the required heterogeneity in a certain instant of time.

$R(x_1, x_2, x_3)$ - uniform distribution in the domain $0 \le x_i \le a_i$

$$R(x_1, x_2, x_3) = \begin{cases} 0 \text{ if } -\infty < x_i \le 0 \\ \frac{1}{a_i} \text{ if } \quad 0 < x_i \le a_i \\ 0 \text{ if } \quad a_i < x_i \le \infty \end{cases}$$

If $R(x)$ is uniform distribution in the domain $0 \le x_i \le a_i$ and $P(x_1, x_2, x_3)$ is also defined in the domain $0 \le x_i \le a_i$, then information divergence is equal to

$$D = -\int\limits_0^a P(x_1,x_2,x_3)\cdot\log_2 \frac{P(x_1,x_2,x_3)}{\frac{1}{\prod\limits_{i=1}^{3} a_i}}\cdot dx_1 dx_2 dx_3 =$$

$$= -\int\limits_0^a P(x_1,x_2,x_3)\cdot\log_2 (\prod_{i=1}^{3} a_i \cdot P(x_1, x_2, x_3)\cdot dx_1 dx_2 dx_3\,.$$

The Consecutive Order of our Reasoning

1. Let us check the correctness of the conjecture about initial information and show that this hypothesis needs clarification.

2. Let us prove the existence of heterogeneities at the initial instant in the Universe.

Let us speculate that there were no heterogeneities in the Universe in the initial instant (information divergence against uniform distribution is equal to zero).

We shall depict that in this case there will not be heterogeneities in the Universe in the posterior moments of time either (information divergence against uniform distribution is equal to zero).

As long as at present it is obvious that there are heterogeneities in the Universe (clusters of galaxies, galaxies, stars, planets,…, molecules, atoms, particles) then under the logic of evidence “ad absurdum” the parent clause is not true.

It follows that in the initial instant there were heterogeneities in the Universe.

3. Let us show that homogeneity of dark energy is conserved at the expansion of the Universe.

Information divergence against uniform distribution is equal to zero at all instants of time.

4. Let us estimate characteristics of initial heterogeneities in the Universe**.**

So far as the very initial heterogeneities contain the laws of nature defining further development of the Universe let us estimate the volume of information contained in laws of nature (following D. Chernavsky [12] we estimate the volume of macro-information or classical information).

The estimate of classical information volume in the laws of nature and the time elapsed from Big Bang, gives estimates of the mass of the initial heterogeneities [10].

5. Let us estimate the growth of heterogeneities at the expansion of the Universe.

We define that at steady expansion of the Universe to “record” physical laws at the initial instant very big mass of heterogeneities is necessary which is apparently impossible.

Let us show that at the inflationary expansion of the Universe from the information contained in the initial heterogeneities of the Universe by the mass 10^4kg the volume of information sufficient for “recording” physical laws is formed.

This will allow clarifying the conjecture about the initial information.

The Estimate of Information Volume in Planck's Particle

The energy necessary for the formation of one bit is no less than $kT\ln 2$ [11, 12-13]. The energy necessary for the formation of one nut is no less than kT. The mass necessary for the formation of one bit is no less than $\frac{kT\ln 2}{c^2}$. The mass necessary for the formation of one nut is no less than $\frac{kT}{c^2}$.

At Planck's temperature $T_{Pl} = \frac{1}{k}\sqrt{\frac{\hbar c^5}{G}} = 1{,}41696 \cdot 10^{32} K$ [14] the mass m_{Nut} necessary for the formation of one nut is no less than Planck's mass

$$m_{Nut} = \frac{kT_{Pl}}{c^2} = \frac{k\frac{1}{k}\sqrt{\frac{\hbar c^5}{G}}}{c^2} = \sqrt{\frac{\hbar c}{G}} = m_{Pl} = 2{,}17671 \cdot 10^{-5} g$$

At Planck's temperature the mass m_{Bit} necessary for the formation of one bit is no less than 0,69 Planck's mass $m_{Pl}\ln 2 \approx 0{,}69 m_{Pl}$:

$$m_{Bit} = \frac{kT_{Pl}\ln 2}{c^2} = \frac{k\frac{1}{k}\ln 2\sqrt{\frac{\hbar c^5}{G}}}{c^2} = \ln 2\sqrt{\frac{\hbar c}{G}} = \ln 2 m_{Pl} \approx 0{,}69 m_{Pl} = 1{,}5 \cdot 10^{-5} g$$

Thus Planck's particle contains one nut of micro-information and one nut can be considered by Planck's unit of information (one bit is Shannon's unit of information).

The size of Planck's particle is 10^{-33}cm. Planck's particle in Planck time $\approx 10^{-44}$ s contains one nut of microinformation (≈1,45bits), while the volume of information about physical laws of the Universe is evidently much greater.

It follows that all the information about the future of the Universe was either contained in the part of the Universe, the radius of which is larger than 10^{-33}cm, or with the exception of initial bit (nut) was born at the expansion of the Universe.

Therefore the conjecture about the initial information should be clarified and developed.

The Proof of Heterogeneity Existence in the Universe at the Initial Instant

We shall estimate the existence of heterogeneity set by the distribution P by the informational divergence $D(P/R)$ of the distribution P as respects to the uniform distribution $R(x)$. Let us prove:

Assertion 1.

Initially there were heterogeneities of usual matter in the Universe

Suppose that at the initial instant t_0 there were no heterogeneities of usual matter: $P(x,t_0) \equiv R(x)$, that is information divergence at certain instant of time $t \geq t_0$ is also equal to zero. It means that at certain instant of time $t \geq t_0$ there were neither heterogeneities of usual matter in the Universe. But as at present there are evidently heterogeneities of usual matter in our Universe (clusters of galaxies, galaxies, stars, planets,…, molecules, atoms, particles [1, 2]) it follows that at the initial instant there were heterogeneity of usual matter in the Universe.

Note 1. This assertion is correct at any physical nature of heterogeneities, at any physical mechanism of heterogeneities generation, any physical model of heterogeneities formation. See for example, [2, 15 - 20]

Note 2. This result gives the strict argumentation by information method to the assertion of Zeldovich with coauthors quoted in the introduction.

Assertion 2.

Initially there existed heterogeneities of dark matter in the Universe.

The deduction is similar to the preceding one.

Assertion 3.

Initially and then there were no heterogeneities of dark energy. The dark energy(vacuum) was evenly distributed.

$$R(x_1, x_2, x_3) = \begin{cases} 0 \text{ if } -\infty < x_i \leq 0 \\ \dfrac{1}{a_i} \text{ if } \quad 0 < x_i \leq a_i \\ 0 \text{ if } \quad a_i < x_i \leq \infty \end{cases}$$

Information divergence $D(P(x)/R(x))$ of dark energy at present is equal to zero.

Then in the initial and posterior instants of time information divergence $D(P(y)/R(y))$ of dark energy is equal to zero.

The Estimate of Characteristics of the Universe's Initial Heterogeneities

Let us estimate the volume of information contained at the initial heterogeneities and mass of the initial heterogeneities.

Let us formulate the required pre-requisites of the estimates

1) Development, properties and characteristics of the Universe are completely defined by laws of nature.

2) Laws of nature are contained in initial heterogeneities of our Universe

(“recorded” in initial heterogeneities of the Universe).

3) Laws of nature are characterized by the volume of classical information I_{Phl}.

4) The volume of classical information $I_{íí}$ in initial heterogeneities of the Universe should be no less than the volume of information in laws of nature $I_{Ih} \geq I_{Phl}$.

The Estimate of the Classical Information Volume Contained in Laws of Nature

It is difficult to define precise meaning of classical information volume contained in laws of nature; therefore we shall give several estimates.

1) If the Universe is described by n parameters then it is necessary to have n^2 of physical laws describing pairwise associations between parameters (taking account of pairwise associations). At occurrence of greater number of interrelated parameters one should take account of greater number of laws.

Let us consider that the description of one law requires I bits. Then for all n^2 physical laws describing the Universe it is necessary to have $I_{Un} = n^2 I$. Let $n = 100$, $I = 1$Gbyte (it is more than 3000 pages of a text – which is obviously inflated estimate) then $I_{Un} = 10000$ Gbytes (10^{14} bytes).

2) The volume of classical information in the course of physics containing 2000 pages is equal approximately to 10^9 bits.

3) The volume of classical information in files describing physical laws [8-9], is approximately equal to 10^7 bits.

4) The volume of information in the file describing Einstein equation [8-9], is approximately equal to 10^6 bits.

Note 3.

Till the instant of time $t = 10^{-44}$s in the Universe the laws acted defining super associated interaction (the interaction integrating gravitational, strong, week and electromagnetic interaction) [1-3].

After the instant of time $t = 10^{-44}$s till the instant $t = 10^{-34}$s in the Universe there acted the laws defining gravitational and great interaction (interaction integrating strong, week and electromagnetic interaction). After the instant of time $t = 10^{-34}$s till the instant $t = 10^{-10}$s in the Universe there acted laws defining gravitational, strong and electroweek interaction.

After the instant of time $t = 10^{-10}$s till recent time in the Universe there act the laws defining all known types of interaction (gravitational, week, strong and electromagnetic interactions).

We shall consider in the following estimates that the laws of nature formed till the instant of time $t = 10^{-10}$s.

The Estimate of Mass of Initial Heterogeneities Defining Development of our Universe

Let us compare the mass required for the formation of one microinformation bit and one bit of classical information (macroinformation). From the estimate of mass redundancy of amino acids and basic nitrogens used for the formation of one bit of classical information with reference to mass required for one bit of microinformation we shall get the value of mass redundancy required for the formation of one bit of classical information

The estimate of mass required for the formation of one bit of microinformation

Energy and mass required for the formation of one bit of microinformation is equal to $E_{bit} = kT \ln 2$, $m_{bit} = (kT \ln 2) / c^2$ [7-10].

The values of energy and mass of one bit of microinformation carrier at the temperatures of 3K and 300K are given in the table 1.

Table 1. *Energy and Mass of Carrier of One Bit of Microinformation*

Temperature	T(K)	3	300
Minimal energy for 1 bit (J)	E = kT	4,14E-23	4,14E-21
Minimal mass for one bit (kg)	$M = kT/c^2$	4,61E-40	4,61E-38

The Estimate of Mass Required for the Formation of One Bit of Classical Information

In general for one bit of classical information in amino acids the mass of 4,43E-25kg is used, redundancy is 9,6E+14 at T = 3K, in basic nitrogens and sugar the mass of 1,05E-25 kg is used in general, redundancy at T = 3K is 1E+14. Thus, we assume that for the formation of one bit of classical information the mass of 10^{15} times greater is needed than the mass required for the formation of one bit mikroinformation.

We shall remark that in general $\approx 1,69 \cdot 10^{-28}$ kg of mass of matter is used in atoms for one bit of information (for example, there is $\approx 1,6 \cdot 10^{-28}$ kg in atoms of hydrogen, $\approx 1,93 \cdot 10^{-28}$ kg in atoms of lithium) which is by $\approx 10^{12}$ times greater than the mass required for the formation of one bit of microinformation.

Estimate of the Mass of the Initial Heterogeneities

Assuming that $E_{bit\ Mi} = kT$, $E_{bit\ cl} \approx 10^{15} E_{bit\ Mi} \approx 10^{15} kT$, then obtain the mass of the initial heterogeneities $m_{Ih} \geq \frac{I_{Ih} \cdot E_{bit\ cl}}{c^2} \geq \frac{I_{Ih} \cdot 10^{15} \cdot kT}{c^2} \geq \frac{I_{Phl} \cdot 10^{15} \cdot kT}{c^2}$.

Because $T = \frac{10^{10}}{t^{1/2}}$, then $m_{Ih} \geq \frac{10^{25} \cdot k \cdot I_{Phl}}{t^{1/2} \cdot c^2}$.

Numerical estimates of the mass of the initial heterogeneities, corresponding to the given volume of classical information in a period from 10^{-35} seconds to one second, are shown in Table 2.

We represent the estimate of mass of the initial heterogeneities for the previous examples.

1) To write a bit of classical information when the current temperature of the Universe T = 2,7 K is required the mass, not less than $M_{bit} = E_{bit} / c^2$ ≈ $10^{15} 10^{-23}$ J/(9 10^{16}m^2/s^2) ≈ 10^{-25}kg, and at T = 2700 K the mass not less than ≈ 10^{-22}kg is required.

2) Let the Universe be described by the n parameters. The mass, which contains information about the Universe (10^{14} bits), must be a minimum 10^{-12}kg (approximately the mass of 10^{15} protons). At the temperature of the Universe T = 2700 K is required the mass not less than 10 ^{9}kg (approximately the mass of 10^{18} protons).

3) The volume of classical information in the course of physics, containing

2,000 pages, is about 10^9 bits. At the temperature of the Universe T = 2,7 K requires the mass no less than 10^{-17}kg, and at T = 2700 K the mass no less than 10^{-14}kg (approximately the mass of 10^{13} protons) is required.

4) The volume of classical information in the files that describe the physical laws is about 10^7 bits. At the temperature of the Universe T = 2,7 K the mass not less than 10^{-19}kg is required, and at T = 2700 K the mass not less than 10^{-16}kg (approximately the mass of 10^{11} protons) is required.

5) The volume of information in a file that describes Einstein equation is approximately 10^6 bits. At the temperature of the Universe T = 2,7 K the mass not less than 10^{-20}kg is required, and at T = 2700 K the mass, not less than 10^{-17}kg (approximately 10^3 the mass of protons) is required. At T = 2,7 10^{12} K requires the mass is not less than 10^{-8}kg (mass of one Planck's particle).

Table 2. *Estimates of the mass of initial heterogeneties containing specified volumes of classical information in certain moments time (at a certain temperature)*

Time (s)	Tempera-ture, K	Energy (Bit/J)	Mass on 10^2 BCI	Mass on 10^4 BCI	Mass on 10^6 BCI	Mass on 10^8 BCI	Mass on 10^10 BCI	Mass on 10^12 BCI	Mass on 10^14 BCI	Mass on 10^16 BCI
1E-35	3,16E+27	4,37E+04	4,86E+04	4,86E+06	4,86E+08	4,86E+10	4,86E+12	4,86E+14	4,86E+16	4,86E+18
1E-34	1,00E+27	1,38E+04	1,54E+04	1,54E+06	1,54E+08	1,54E+10	1,54E+12	1,54E+14	1,54E+16	1,54E+18
1E-32	1,00E+26	1,38E+03	1,54E+03	1,54E+05	1,54E+07	1,54E+09	1,54E+11	1,54E+13	1,54E+15	1,54E+17
1E-30	1,00E+25	1,38E+02	1,54E+02	1,54E+04	1,54E+06	1,54E+08	1,54E+10	1,54E+12	1,54E+14	1,54E+16
1E-20	1,00E+20	1,38E-03	1,54E-03	1,54E-01	1,54E+01	1,54E+03	1,54E+05	1,54E+07	1,54E+09	1,54E+11
1E-10	1,00E15	1,38E-08	1,54E-08	1,54E-06	1,54E-04	1,54E-02	1,54E+00	1,54E+02	1,54E+04	1,54E+06
1E-06	1,00E+13	1,38E-10	1,54E-10	1,54E-08	1,54E-06	1,54E-04	1,54E02	1,54E+00	1,54E+02	1,54E+04
1E-05	3,16E+12	4,37E-11	4,86E-11	4,86E-09	4,86E-07	4,86E-05	4,86E03	4,86E-01	4,86E+01	4,86E+03
1E-04	1,00E+12	1,38E-11	1,54E-11	1,54E-09	1,54E-07	1,54E-05	1,54E03	1,54E-01	1,54E+01	1,54E+03
1E-03	3,16E+11	4,37E-12	4,86E-12	4,86E-10	4,86E-08	4,86E-06	4,86E04	4,86E-02	4,86E+00	4,86E+02
1E-02	1,00E+11	1,38E-12	1,54E-12	1,54E-10	1,54E-08	1,54E-06	1,54E04	1,54E-02	1,54E+00	1,54E+02
1E-01	3,16E+10	4,37E-13	4,86E-13	4,86E-11	4,86E-09	4,86E-07	4,86E05	4,86E-03	4,86E-01	4,86E+01
1E+00	1E+10	1,38E-13	1,54E-15	1,54E-11	1,54E-09	1,54E-07	1,54E-05	1,54E-03	1,54E-01	1,54E+01

BCI - bits of classical information

Table 3 shows the estimates of the mass of the initial heterogeneities of the Universe necessary for the storage of classical information about physical laws that contain 10^2 - 10^{12} bit

Table 3.

Time from the beginning (s)	Temperature (K)	Mass (kg)/ 10^6 BCI	Mass (kg)/ 10^7 BCI	Mass (kg))/ 10^8 BCI
1,00E-44	1,00E+32	1,54E+11	1,54E+12	1,54E+13
1,00E-35	3,16E+27	4,86E+06	4,86E+07	4,86E+08
1,00E-05	3,16E+12	4,86E-09	4,86E-08	4,86E-07
1,00E+00	1,00E+10	1,54E-11	1,54E-10	1,54E-09

Table 4 shows the minimum and maximum estimates of the mass of initial heterogeneities of the Universe which is necessary for the storage of classical information about physical laws that contain 10^2 and 10^{14} bits.

Table 4.

Time from the beginning (s)	Temperature (K)	Mass (kg)/ 10^2 BCI	Mass (kg)/ 10^14 BCI
1,00E-44	1,00E+32	1,54E+09	1,54E+21
1,00E-35	3,16E+27	4,86E+04	4,86E+16
1,00E-05	3,16E+12	4,86E-11	4,86E+01
1,00E+00	1,00E+10	1,54E-13	1,54E-01

Growth of Heterogeneities in the Expanding Universe

Consider the transition from the coordinates $x = (x_1,...,x_n)$ to the coordinates $y = (y_1,...,y_n)$. The new value of uncertainty (information) [6, 8], characterizing the physical system in the new coordinates is equal to the old one minus the average value of the logarithm of the Jacobian [5]:

$$N_y = -\int ...\int\ p(y_1,...,y_n))\ln p(y_1,...,y_n)dy_1...dy_n = N_x - \int ...\int\ p(x_1,...,x_n)\ln J(\frac{x_1,...,x_n}{y_1,...,y_n})dx_1...dx_n$$

.

Consider the linear transformation of coordinates $y = Ax$ or $y = \|a_{ij}\|x$. In this case the Jacobian is the determinant inversion transformation of coordinates $\|a_{ij}\|^{-1}$.

With the expansion of the Universe

$$y=kx,\ y_i=kx_i\ \ i=1,2,3\ \textbf{or}\ \begin{pmatrix} y_1 \\ y_2 \\ y_3 \end{pmatrix} = \begin{Vmatrix} k & 0 & 0 \\ 0 & k & 0 \\ 0 & 0 & k \end{Vmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}.$$

$J = |a_{ij}|^{-1} = \begin{vmatrix} 1/k & 0 & 0 \\ 0 & 1/k & 0 \\ 0 & 0 & 1/k \end{vmatrix} = \frac{1}{k^3}$ and with the transition from the coordinate system $x=(x_1, x_2, x_3)$ to the coordinate system $y=(y_1, y_2, y_3)$ new value of uncertainty (information) is equal to the old value of uncertainty (information) minus the logarithm of the determinant of the inverse transformation of coordinates: $N_y = N_x - \ln\frac{1}{k^3} = N_x + 3\ln k$.

Change of the uncertainty is $\Delta N = N_y - N_x = 3\ln k$ *. By the law of conservation of uncertainty (information) [6, 8], a closed (isolated) systems change uncertainties in the system accompanied by a corresponding change of the information in the system. With increasing uncertainty in the system the amount of information in the system increases. Change of the uncertainty ΔN leads to a corresponding change in the amount of information ΔI:* $\Delta I = \Delta N$ *or* $\Delta I - \Delta N = 0$.

The uncertainty of an isolated system is conserved, whereas there may be a variety of processes defined by its own laws. If during the expansion of the universe uncertainty of particles increases (decreases), then the Universe should be formed (deformed) information in the form of heterogeneities. That is a consequence of the law of conservation of uncertainty [7, 11] which together with other laws can explain the phenomenon of heterogeneous evolving the Universe. Consequently, the initial heterogeneities and expansion of the universe leads to the formation information which a compensating increase in uncertainty $\Delta I = \Delta N = 3\ln k$.

When the Universe expands from the size which is characterized by the value R_0 to the size which is characterized by the value R , the volume of information per particle, formed by extension, is equal to $3\log_2\frac{R}{R_0}$ bits.

With the expansion of the universe from the Planck's length $10^{-33}cm$ to the current size $10^{28}cm$ the volume of information that is generated by extension of Universe, is equal to 607.8 (bits). With the expansion of the Universe dominated by matter to the current size the volume of information per particle, formed by extension, is equal to 109.6 (bits).

The Growth of Heterogeneities in the Sedate and Inflationary Expansion of the Universe

When the sedate expansion of the Universe during the period 10^{-34} – 10^{-10}s from one bit of classical information approximately 160 bits of classical information is formed. Consequently, to obtain 10^7 bits of classical information in time 10^{-10}s there were been approximately 10^5 bits of classical information at the time $10^{-34}s$ - the mass of the order of 10^7kg, this is apparently impossible. Therefore, the initial information was largely formed during the inflationary expansion of the Universe.

Let the radius of the Universe increases as $r(t) \propto e^{\alpha t}$, where α is degree of exponent. Then at the moment $t_0 + t$ the volume of information is equal to

$$I(t_0 + t) - I(t_0) = \log_2 \frac{V(t_0 + t)}{V(t_0)} = \log_2 \frac{r^3(t_0 + t)}{r^3(t_0)} = 3\log_2 \frac{r(t_0 + t)}{r(t_0)} = 3\log_2 \frac{e^{\alpha(t_0 + t)}}{e^{\alpha t_0}} = 3\log_2 e^{\alpha t} = \alpha t \cdot 3\log_2 e.$$

We obtain the evaluation (α = 1,15E+34 1/sec) from the ratio of $r(10^{-32}s) = 10^{50} r(10^{-34}s)$.

With inflationary expansion of the universe during the period from 10^{-34}s - 10^{-32}s from one bit of classical information contained in the initial heterogeneities of the Universe, it is generated about 10^3 bits of classical information.

During the further sedate extension of the Universe from instant $10^{-32}s$ to instant $10^{-10}s$ from each bit of the classical information it was formed about 150 bits of the classical information.

Therefore, at the inflationary extension in 10^{-34}s with - 10^{-32}s and the further sedate extension of the Universe in $10^{-32}s$ - $10^{-10}s$ from one classical bit of the information it is formed about 10^5 bits of classical information.

Thus, the classical information formed from Plank's particle obviously is not enough for "recording" of the laws of nature. For creation to the moment $10^{-10}s$ about 10^7 bits of the classical information is necessary to have at the moment of $10^{-34}s$ about 10^2 bits of initial classical information and, accordingly, the mass of heterogeneities of the Universe of the order 10^4kg, is necessary for "recording" the laws of nature.

Such is an estimate of the mass of the initial heterogeneity containing all laws of nature at moment $10^{-10}s$.

If the mass of 1 bit is the estimate for atom of hydrogen (proton) (10^{-28}кг) the mass of initial heterogeneities at the instant $10^{-34}s$ is about 10kg.

If the mass of 1 bit is the estimate for neutrino (10^{-36}kg) (minimum possible estimate) the mass of initial heterogeneities at the instant $10^{-34}s$ is about 10^{-7}kg.

It testifies in favor of the improved hypothesis to the initial information: “Some fourteen billion years ago, at the instant $10^{-34}s$ all the Universe consisted of one place with the radius of 10^{-24}cm. In that volume all the information about the future of the Universe was contained…”.

The volume of microinformation in the Universe is equal now the $\approx 10^{90}$ bits [6-11]. The volume of the classical information in the Universe now is no more than $\approx 10^{75}$ bits.

Conclusion

The results obtained with the help of information methods allow us to make the following basic conclusions.

1. In this paper, information methods studied, refined and developed the hypothesis of initial information: “…at the moment of birth, all the Universe consisted of one place with the radius of 10^{-33}cm... In that volume all the information about the future of the Universe was contained”
2. It is shown that initial heterogeneities of ordinary matter and dark matter in the Universe existed. This assertion is correct at any physical nature of heterogeneities, at any physical mechanism of heterogeneities generation, any physical model of heterogeneities formation.
3. It is shown that the initial heterogeneities of dark energy in the Universe did not exist.
4. As the very initial heterogeneities contain laws of the nature defining further development of the Universe it allows us to estimate the volume of information contained in the laws of nature. The estimate of classical information volume in laws of the nature and temporal value from the appearance of the Universe make it possible to estimate the mass of initial heterogeneities.
5. From for creation to the moment $10^{-10}s$ about 10^7 bits of classical information necessary to have at the moment of $10^{-34}s$ about 10^2 bits of initial classical information and, accordingly, the mass of heterogeneities of the Universe of the order 10^4kg, are necessary for "recording" of the laws of nature. Such is an estimate of the mass of initial heterogeneity containing all laws of nature at moment $10^{-10}s$.
6. The improved hypothesis to the initial information: “Some fourteen billion years ago, at the instant $10^{-34}s$ all the Universe consisted of one place with the radius of 10^{-24}sm. In that volume all the information about the future of the Universe was contained…”.

7. It is necessary to identify the initial heterogeneities with concrete physical objects.
8. We need to understand how in the heterogeneities of the Universe the laws of nature are written, physical laws and they how are implemented.

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