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**Information Laws  
(Informatics Laws) of Nature**

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## **Information Laws (Informatics Laws) of Nature**

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### **Abstract**

The report includes the following questions: The information laws (informatics laws) of nature. Description of physical systems. Information restrictions and reliability of physical transformations. Properties of space-time. Physical laws as consequence of informatics laws. Estimation of the volume of information in some fundamental, elementary particles, atoms and cosmological objects.

### **Keywords:**

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## Introduction

Information is an integral part of the Universe. The basic law of Zeilinger's quantum mechanics postulates that an elementary physical system (in particular, fundamental particles: quark, electron, photon) bears one bit of information. By its physical essence information is heterogeneity of matter and energy. Therefore information is inseparably connected with matter and energy. The universal measure of physical heterogeneity of information is the Shannon information entropy. Information approach along with a physical one allows to obtain new, sometimes more general data in relation to data obtained on the ground of physical rules only. The author's works testify about the practicality of information laws usage simultaneously with physical rules for cognition of the Universe.

### Information Laws (informatics laws) of Nature are [1-5].

*The main principle of quantum mechanics by A. Zeilinger: Elemental physical systems contain (carry) one bit of information [1].*

*The law of simplicity of complex systems. Such variant of complex system is realized, survives which possesses the minimum complexity. The law of simplicity of complex systems is realized by nature in a number of constructive principles: " Occam Razor "; hierarchical modular construction of complex systems; symmetry; *simmorfoz*, stability; field interaction (interaction through the carrier or interactions through space-time status, for example, curvature of space-time); extreme uncertainty (functions of characteristics distribution have extreme uncertainty).*

*The law of conservation of uncertainty (information). Uncertainty (information) of the isolated (closed) systems is saved at physically realized transformations and only at physically realized transformations.*

*The law of finiteness of information characteristics of complex systems. All kinds of interaction between systems, their parts and elements have final speed of distribution. The speed of system states change of elements is also limited. In any system of coordinates information on event is always final. Duration of signal  $\Delta T$  is always more than zero ( $\Delta T > 0$ ). Information on coordinates of physical systems in our Universe is limited by 333 bits.*

*The law of necessary variety by W. Ashby. For effective functioning of system a variety of operating body should be no less than variety of management object. Uncertainty (information) is the basic characteristic of a variety of systems. The law of necessary variety by W. Ashby is also realized in a number of concrete principles: Shannon theorems, Kotelnikov theorem, Kholevo theorem, Brillouin theorem, theorem of Margolis-Levitin.*

*Gödel theorem of incompleteness. In the rich enough theory (containing arithmetic) there are always unprovable true assertions.*

*The law of systems complexity growth. During systems evolution its uncertainty (systems information) grows.*

*Le Chatelier Principle. External influence decomposing system, calls in it the processes, aspiring to weaken results of this influence.*

## **Physical Laws and Properties of Nature as Consequence of Informatics Laws**

### *The Universe's Structure*

**Assertion 1.** *The Universe is arranged by the simplest images. The description (theoretical model) of the Universe should be the simplest. Simplicity, complexity of systems is defined by information volume contained in them (volume of information necessary for their description).*

**Assertion 2.** *The Universe represents hierarchical set of physical systems.*

From a principle of hierarchical construction of complex systems, of the law of simplicity of complex systems follows the proof that complex systems have hierarchical modular structure.

### *Classical and Quantum Physics*

**Assertion 1.** *Axioms of classical and quantum physics can be formulated in a classic language. The classical logic - the term used in the mathematical logic in relation to this or that logic system, indicates that for the given logic all laws of (classical) calculation of assertions, including the law of an exception of the*

*third, are fair. The multitude of axioms of classical and quantum physics is limited and is consistent. There are no indemonstrable true assertions among them.*

**Assertion 2.** *All assertions about physical systems cannot be formulated in a classic language. For the formulation of assertions about physical systems the language of quantum physics should be used. Owing to Gödel theorem the physics can not be limited to classical theories in which frameworks there are always indemonstrable true expressions that describe potentially unlimited number of assertions about physical systems. It explains obligatory existence of the quantum physics describing physical systems by probability characteristics.*

**Assertion 3.** *Application of the principle of the maximum information entropy at restrictions on the sum of probabilities of ways (=1) and the average action allows to receive distribution of probabilities of ways, statistical sum, average action and wave function of a way [9]. The quantum mechanics based on the theory of information demands introduction of the basic physical principle: existence of the universal pool of action similar to the thermostat for initial ensemble. Canonical ensemble - statistical ensemble, responding physical system which exchanges energy with environment (thermostat), being from it in thermal balance, but does not exchange substance as it is separated from the thermostat by an impenetrable partition for particles. The description of the system in the form of Feynman integral is*

$Z = \sum_{path} e^{-\frac{1}{i\hbar}S}$ . The sum (integral) on all ways to classical configuration

space, and  $S$  - the classical action set for each way. Each observer interacts with probability,  $p[path] = p[q(t)]$  (in abbreviated form  $p[q]$ ). The information - the negative logarithm of probability for a way -  $-\log p[path]$  is - quantity of information received by the observer if the system is on a corresponding way. The information entropy characterizing the system, is equal to  $H = -\sum_{path} p[path] \log_2 p[path] = -\int Dqp[q] \log_2 p[q]$ . For any system

restriction is  $1 = \sum_{path} p[path] = \int Dqp[q]$ . In case of statistical thermodynamics it

is supposed, that the system is in balance with the thermostat of the set temperature. Similarly, in the quantum mechanics it is supposed, that the system is in balance with universal storehouse of actions.

$\bar{S} = \langle S \rangle = -\sum_{path} p[path] S[path] = -\int Dqp[q] S[q]$ . Maximizing entropy, taking

into account the resulted restrictions, we will receive distribution of

probabilities of ways, the statistical sum and average action:  $p[q] = \frac{1}{Z} e^{-\alpha S[q]}$ ,

$Z = \int Dqe^{-\alpha S[q]}$ ,  $\bar{S} = \int DqS[q]p[q] = -\frac{\partial}{\partial \alpha} \log_2 Z$ .  $\alpha = \frac{1}{i\hbar}$ .  $i\hbar \leftrightarrow k_B T$ . The

probability of a choice of way  $p(q', t') = \Psi(q', t') \Psi^*(q', t')$  is expressed through

wave function  $\Psi(q', t') = \frac{1}{\sqrt{Z}} \int_0^{q(t')=q'} Dqe^{-\alpha S t'}$ .

**Assertion 4.** Combination of classical addition of probabilities of distinguishable alternatives to a classical choice of one of several equiprobable ways leads to quantum mechanical wave rule of addition of amplitudes. Let's consider transition of object from an initial state  $s$  to the final state  $f$  in two distinguishable ways. According to the rule of addition of probabilities of independent events the probability of this transition is equal to  $\omega_{s \rightarrow f} = \omega_{1 s \rightarrow f} + \omega_{2 s \rightarrow f}$ , or  $|\langle f | s \rangle|^2 = |\langle f | s \rangle_1|^2 + |\langle f | s \rangle_2|^2$ . At identical to each way probability of uncertainty is equal to amplitude of probability of transition  $N_{2 s \rightarrow f} = -\log_2 2|\psi|^2$ . At two indiscernible ways of transition from uncertainty of transition two distinguishable ways subtract the information of a choice of one of two equiprobable ways of transition  $I_2 = -\log_2 2 = -1$ . Hence, uncertainty of transition of object from an initial state  $s$  to the final state  $f$  will be equal in two indiscernible ways to the sum of uncertainty of transition in two distinguishable ways and information of a choice of one of two equiprobable ways of transfer (with a return sign):  $N_{2 s \rightarrow f} = N_{2 s \rightarrow f} - I_2 = -\log_2 2|\psi|^2 - \log_2 2 = -\log_2 4|\psi|^2 = -\log_2 |2\psi|^2$ . The size standing under the sign of the module expresses a rule of addition of amplitudes of transition probability. Let's consider transition of object from an initial state to the final state  $f$  by  $m$  distinguishable ways. According to the rule of addition of probabilities of



independent events the probability of this transition is equal to  $\omega_{s \rightarrow f} = \sum_i \omega_i \omega_{s \rightarrow f}$ , or  $|\langle f | s \rangle|^2 = \sum_i |\langle f | s \rangle_i|^2$ . At identical to each way of transition uncertainty of transition of bits is equal to amplitude of probability of transition  $N_{m \rightarrow f} = -\log_2 m |\psi|^2$ . At indiscernible ways of transition to uncertainty of transition for  $m$  distinguishable ways the information of a choice of one of  $m$  equiprobable ways (with a minus sign) is added:  $I_m = \log_2 m$ . Hence, uncertainty of transition of object from an initial state to the final state  $f$  indiscernible  $m$  will be equal to the sum of uncertainty of transition for distinguishable  $m$  ways and uncertainty of a choice of one of  $m$  equiprobable ways of transition:  $N_{m \rightarrow f} = N'_{m \rightarrow f} - I_m$ .  $N_{m \rightarrow f} = -\log_2 m |\psi|^2 - \log_2 m = -\log_2 m^2 |\psi|^2 = -\log_2 |m\psi|^2$ . The size standing under the sign of the module expresses the rule of addition of amplitudes of transition probability. The combination of classical addition of probabilities at distinguishable alternatives with a classical choice of one of several equiprobable ways leads to quantum mechanical wave rule of amplitudes addition.

*Description of Physical Systems*

**Assertion 1.** *Physical systems, the objects observed are described by wave function or the amplitude of probability depending on quality parameters and variables physical characteristics.*

**Assertion 2.** *The square of the module of wave function or amplitude of probability is density of probability or probability.*

**Assertion 3.** *Physical systems, objects, the observable are described by the information characteristic - uncertainty (information). A measure of uncertainty (information) is the Shannon information entropy, defined as functional on wave function or amplitudes of probability. C. Shannon [3] has entered the concept of information entropy. Entropy  $H$  of a discrete random variable:  $H = -\sum p_i \log_2 p_i$  [bit] ( $H = -\sum p_i \ln p_i$  [nut]), Entropy  $H$  of a continuous random variable  $H(x) = -\int p(x) \log_2 p(x) dx$  [bit], ( $H(x) = -\int p(x) \ln p(x) dx$  [nut]).*

**Assertion 4.** *Heterogeneity of physical system is described by the information characteristic of divergence, defined as functional on wave function or amplitudes of probability. Presence and properties of the heterogeneity set by distribution  $P$ , will estimate information divergence  $D(P/R)$  distributions  $P$  concerning uniform distribution  $R$   $D(P/R) = -\int P(x) \cdot \log_2 (P(x)/R(x)) \cdot dx$ . Where  $P(x)$  - the distribution corresponding to heterogeneity, and  $R(x)$  uniform distribution to interval  $0 \leq x \leq a$ .  $R(x) = 0$  if  $-\infty < x \leq 0$ ,  $a < x \leq \infty$ ;  $1/a$  if  $0 < x \leq a$ . If  $P(x)$  is defined on interval  $0 \leq x \leq a$  information divergence is equal to*

$$D = -\int_0^a P(x) \cdot \log_2 (a \cdot P(x)) dx = -\log_2 a - \int_0^a P(x) \cdot \log_2 P(x) dx = N \cdot \log_2 a .$$

Information divergence concerning uniform distribution differs from uncertainty (information entropy) on  $-\log_2 a$ .

**Assertion 5.** *Unitary transformations are described by the information characteristic - joint entropy.* Let's define for the unitary operator

(transformation), unitary matrix  $U = \left\| u_{ij} \right\|$  Shannon matrix

$SH(U) = \left\| u_{sh\ ij} \right\| = \left\| u_{ij} / \sqrt{n} \right\|$ ,  $i, j = 1, \dots, n$  which elements are elements of

a unitary matrix, divided by  $\sqrt{n}$ . Let's define on Shannon matrix the final probability space: set  $\Omega$  of elementary events (outcomes) is made by steams of basic vectors  $y_i, x_j$  bases  $y$  and  $x$ ; their probability measure is set by

squares of modules of elements Shannon's matrixes  $p_{ij}(SH(U)) = |u_{ij}|^2 / n$ .

(probability of joint realization of states  $y_i$  and  $x_j$  at measurement of states

$y$  in basis  $x$ ).  $\sum_{i,j=1}^n p_{ij}(SH(U)) = \sum_{i,j=1}^n |u_{ij} / \sqrt{n}|^2 = (1/n) \sum_{i,j=1}^n |u_{ij}|^2 = 1$ . At such

definition of final probability space for considered unitary matrix  $U = \left\| u_{ij} \right\|$  at

measurement of states  $y$  in basis  $x$  the probability of realization  $y_i$  and  $x_j$  is

equal to  $p_{ij}(SH(U)) = (1/n) |u_{ij}|^2$ ,

$$\sum_{i=1}^n p_{ij}(SH(U)) = (1/n) \sum_{i=1}^n \sum_{j=1}^n p_{ij}(SH(U)) = \sum_{i=1}^n \sum_{j=1}^n (1/n) |u_{ij}|^2 = 1.$$

Thus, the matrix of joint probabilities  $P(SH(U)) = \left\| \left\| u_{sh\ ij}(U) \right\|^2 \right\| = \left\| |u_{ij}|^2 / n \right\|$  is

defined on Shannon's matrix to a matrix unequivocally. Using a matrix of joint probabilities, we will define the joint entropy corresponding to unitary matrix

$$U = \left\| u_{ij} \right\|. H(U) = H(P(SH(U))) = - \sum_{i=1}^n \sum_{j=1}^n (|u_{ij}|^2 / n) \log_2 (|u_{ij}|^2 / n).$$

**Assertion 6.** *Interaction of physical systems, objects is described by the information characteristic - mutual uncertainty (mutual information).*

The mutual information entropy  $I_{xy}$  of random variables  $x$  and  $y$  is equal to

[3].  $I_{xy} = N_x + N_y - N_{xy}$ , where  $N_x, N_y$  - uncertainty (information entropy)

random variables  $x$  and  $y$ ;  $N_{xy}$  - joint uncertainty (information entropy)

random variables  $(x, y)$ . The mutual information can be considered as a measure of entanglement of physical systems.

*Information Restrictions on Physical Transformations*

**Assertion 1.** Transformations  $U$  of the state  $|\psi\rangle = \sum_x c_x |x\rangle$  in the complex Euclidean space, saving probability structure of a state (the sum of probabilities received at measurement of one of the basic states  $x$  for the initial state  $|\psi\rangle = \sum_x c_x |x\rangle$  equal to unit  $\langle |\psi\rangle || |\psi\rangle \rangle = \sum_x |c_x|^2 = 1$ , and the sum of probabilities received at measurement of one of basic states  $x$  for the final state  $U|\psi\rangle = U \sum_x c_x |x\rangle = \sum_x c_{ux} |x\rangle$  equal to unit  $\langle |U\psi\rangle || |U\psi\rangle \rangle = \sum_x |c_{ux}|^2 = 1$ ), are unitary.

**Assertion 2.** Transformations  $O$  of the state  $|\psi\rangle = \sum_x c_x |x\rangle$  in the real Euclidean space, saving probability structure of the state (the sum of probabilities received at measurement of one of the basic state  $x$  for the initial state  $|\psi\rangle = \sum_x c_x |x\rangle$  equal to the unit  $\langle |\psi\rangle || |\psi\rangle \rangle = \sum_x |c_x|^2 = 1$ , and the sum of probabilities received at measurement of one of the basic states  $x$  for the final state  $O|\psi\rangle = O \sum_x c_x |x\rangle = \sum_x c_{ox} |x\rangle$ , equal to the unit  $\langle |O\psi\rangle || |O\psi\rangle \rangle = \sum_x |c_{ox}|^2 = 1$ ), are orthogonal.

**Assertion 3.** Transmitting transformations are the simplest. Such movement of space at which the movement of all points is equal to  $y = x + z$  is called translation motion (shift). Transmitting transformations of coordinates in  $n$ -dimensional Euclidean space  $E^n$  are defined by no more than  $n$  parameters that is less in comparison with other kinds of transformations.

**Assertion 4.** Linear transformations of coordinates, as well as transmitting, are the simplest transformations. Linear transformations of coordinates in  $n$ -dimensional Euclidean space  $E^n$  are defined by no more than  $n^2$  parameters that is less in comparison with other kinds of transformations, except the transmitting ones.

**Assertion 5.** The real variables are the simplest. Real variables are described by one number, and complex ones are described by two numbers.

**Assertion 6.** In the Universe transmitting transformations of coordinates operate as the simplest.

**Assertion 7.** In the Universe linear transformations of coordinates operate as the simplest.

**Assertion 8.** The observable is the real variable as the simplest.

**Assertion 9.** At transformations of systems of coordinates uncertainty (information) is saved in that and only in that case when Jacobean transformations is equal to unit:  $J(x_1, \dots, x_n / y_1, \dots, y_n) = 1$ . Let's consider

transition from coordinates  $x = (x_1, \dots, x_n)$  to coordinates  $y = (y_1, \dots, y_n)$  -  $y = y(x)$ . Let  $N_x, N_y$  values of the uncertainty (information) characterizing physical system in coordinates  $x$  and  $y$ ,  $p(x) = |\psi(x)|^2$ ,  $p(y) = |\psi(y)|^2$ .

$$N_y = -\int \dots \int p(y_1, \dots, y_n) \ln p(y_1, \dots, y_n) dy_1 \dots dy_n =$$

$$= N_x - \int \dots \int p(x_1, \dots, x_n) \ln J(x_1, \dots, x_n / y_1, \dots, y_n) dx_1 \dots dx_n.$$

The law of simplicity of complex systems demands realization in the Universe of linear transformations of co-ordinates (as the simplest). Let's consider further linear transformations of coordinates  $y = Ax$  or  $y = \|a_{ij}\|x$ . In this case Jacobean is equal to a determinant of return transformation of coordinates  $\det \|a_{ij}\|^{-1}$  and the value of the uncertainty (information) characterizing physical system in new coordinates, is equal to

$$N_y = -\int \dots \int p(y_1, \dots, y_n) \ln p(y_1, \dots, y_n) dy_1 \dots dy_n =$$

$$= N_x - \int \dots \int p(x_1, \dots, x_n) \ln (\det \|a_{ij}\|^{-1}) dx_1 \dots dx_n.$$

**Assertion 10.** *Uncertainty (information) is saved in that and only in that case, when the value of a determinant of linear transformation of coordinates is equal to one unit.*

**Assertion 11.** *At global gauge transformations  $\psi'(x) = e^{i\alpha} \psi(x)$ ,  $\alpha = \text{const}$  uncertainty (information) is saved. Let's estimate  $\bar{\psi}'(x)\psi'(x) = e^{-i\alpha} \bar{\psi}(x) e^{i\alpha} \psi(x) = e^{-i\alpha} e^{i\alpha} \bar{\psi}(x)\psi(x) = \bar{\psi}(x)\psi(x)$ . ( $e^{-i\alpha}$  and  $\bar{\psi}(x)$  - as complex numbers switch). Hence,  $-\int |\psi'(x)|^2 \log_2 |\psi'(x)|^2 dx = -\int |\psi(x)|^2 \log_2 |\psi(x)|^2 dx$  - uncertainty (information) is saved.*

**Assertion 12.** *At local gauge transformations  $\psi'(x) = e^{i\alpha(x)} \psi(x)$  uncertainty (information) is saved. Let's estimate  $\bar{\psi}'(x)\psi'(x) = e^{-i\alpha(x)} \bar{\psi}(x) e^{i\alpha(x)} \psi(x)$ . As  $\psi(x)$  - complex number, and  $e^{i\alpha(x)}$ , generally a matrix,  $e^{-i\alpha} \bar{\psi}(x)\psi(x) e^{i\alpha} = e^{-i\alpha} |\psi(x)|^2 e^{i\alpha} = |\psi(x)|^2 e^{-i\alpha} e^{i\alpha} = |\psi(x)|^2$  (complex number  $\psi(x)$  switches with matrix  $e^{-i\alpha(x)}$ ). Hence,  $-\int |\psi'(x)|^2 \log_2 |\psi'(x)|^2 dx = -\int |\psi(x)|^2 \log_2 |\psi(x)|^2 dx$  - uncertainty (information) is saved.*

**Assertion 13.** *Observables as real variables are represented by Hermitian operators.*

*Reliability of physical transformations*

**Assertion 1.** *Transmitting transformations save uncertainty (information), therefore owing to the law of conservation of uncertainty (information), they are physically realized.* Owing to the law of conservation of uncertainty, transformations of the isolated (closed) systems are physically realized in the only case when they save uncertainty (information). Jacobean matrix transmitting transformation  $y_i = x_i + z_i$  is equal to identity matrix  $J(x_1, \dots, x_n / y_1, \dots, y_n) = E$ . The determinant Jacobean matrix transformation of translation (shift) is equal to one unit. The physical reliability of transmitting transformations directly follows from the law of conservation of uncertainty (information): uncertainty (information) of the isolated (closed) system is saved at physically realized transformations and only at physically realized transformations.

**Assertion 2.** *Own rotations are conservation uncertainty (information), therefore owing to the law of conservation of uncertainty (information), they are physically realized.* Unitary transformations with a determinant equal to one unit are transformations of its own rotation. Such transformations save uncertainty (information), hence, in the isolated (closed) systems they are physically realized.

**Assertion 3.** *Transformations of classical mechanics (Galilee transformations) save uncertainty (information), therefore owing to the law of conservation of uncertainty (information), they are physically realized.* Galilee transformations leave invariable the interval  $ds^2 = dx_1^2 + dx_2^2 + dx_3^2$ . They can be formally considered as rotation in Euclidean 3-dimensional space. Galilee transformations consist of three independent rotations in planes  $x_i x_j$  and three transformations responding to arbitrariness in the choice of the beginning of coordinates system of  $x_\mu \rightarrow x_\mu + a_\mu$  (transmitting transformations). All of them save uncertainty. Hence, Galilee transformations in the isolated (closed) systems are physically realized.

**Assertion 4.** *Transformations of the special theory of relativity (Lorentz transformation) save uncertainty (information), therefore owing to the law of conservation of uncertainty (information), they are physically realized.*

Lorentz transformations leave invariable the interval  $ds^2 = dt^2 - dx_1^2 - dx_2^2 - dx_3^2$ . They can be considered formally as rotation in pseudo-Euclidean 4-dimensional space-time (Minkovsky space) for which turn generators in planes  $tx_1, tx_2, tx_3$  are purely imaginary. Physically they respond to transition system of coordinates moving along the set of axes  $x_i$ . Transformations to planes  $x_i x_j$  are usual rotations. Therefore Lorentz transformations consist of three independent rotations in planes  $x_i x_j$  and three

independent movements along the axes  $x_i$ . Besides these six transformations of symmetry in Minkovsky space four more are admissible, responding to arbitrariness in the choice of the beginning of system of coordinates  $x_\mu \rightarrow x_\mu + a_\mu$  (transmitting transformations). All of them save uncertainty. Hence, Lorentz transformations in the isolated (closed) systems are physically realized.

**Assertion 5.** *Reflexions, not own rotations, time inversion in isolated (closed) system are forbidden and physically unrealizable.*

Reflexions, not own rotations, time inversion are forbidden and physically unrealizable as determinants of corresponding transformations are equal to a minus unit.

**Remark 3.** According to the law of conservation of uncertainty (information) an isolated (closed) physical system cannot pass from the state  $\psi(x)$  in the state  $\psi(-x)$  (reflexion), from the state  $\psi(x)$  in the state  $\psi(-x)$  (not own rotation) and from the state  $\psi(x,t)$  in the state  $\psi(x,-t)$  (time inversion), but the systems described by the wave functions  $\phi(x) = \psi(-x)$ ,  $\phi(x) = \psi(-Ux)$ ,  $\phi(x,t) = \psi(x,-t)$  can exist.

**Assertion 6.** *Global gauge transformations  $\psi'(x) = e^{i\alpha} \psi(x)$ ,  $\alpha = const$  save uncertainty (information), therefore owing to the law of conservation of uncertainty (information), they are physically realized.*

**Assertion 7.** *Local gauge transformations  $\psi'(x) = e^{i\alpha(x)} \psi(x)$  save uncertainty (information), therefore owing to the law of conservation of uncertainty (information), they are physically realized.*

#### *Properties of Space-time*

**Assertion 1.** *The physical [realizability](#) of transmitting transformation of time means uniformity of time.*

The given Assertion follows from the definition of uniformity of time.

**Assertion 2.** *The physical [realizability](#) of transmitting transformation of space means uniformity of space.*

The given Assertion follows from the definition of uniformity of space.

**Assertion 3.** *The physical realizability of transformation of own rotation of space means isotropy of space.*

The given assertion follows from the definition of own rotation of space.

#### *Physical Laws as Consequence of Informatics Laws*

**Assertion 1.** *Spatial uncertainty (information on a particle arrangement in space) defines Newton gravitational potential and Coulomb potential (the first derivative of uncertainty on radius), intensity of gravitational field and Coulomb's fields (the second derivative of uncertainty on radius). Newton gravitational potential in point  $b$  created mass  $M_a$ , being in point  $a$  and,  $\phi = -G \cdot M_a / r_{ab}$ , where  $G$  - a gravitational constant,  $r_{ab}$  - distance from*

point  $a$  to point  $b$ . Potential energy of a body with mass  $m_b$ , being in point  $b$ , is equal to  $\phi \cdot m_b$ , i.e.  $\phi$  potential energy of a body of individual mass in the given point of gravitational field, and intensity of a gravitational field is equal to the gradient of gravitational potential. Let's consider three-dimensional Euclidean space  $R^3$ . We will allocate in him a sphere with radius  $r$  and volume  $V = (4/3)\pi r^3$ . We will assume, that in the sphere there is a particle which radius is equal to  $r_0$  and volume  $V_0 = (4/3)\pi r_0^3$ . Uncertainty of a particle arrangement in a sphere (spatial uncertainty of a particle) is equal to  $N = \log_2(V/V_0) = 3\log_2(r/r_0) = 3\log_2 r - 3\log_2 r_0$ . The first derivative of uncertainty on radius  $dN/dr = (3/\ln 2) \cdot 1/r$  to within a constant is gravitational potential of unit mass. The second derivative of uncertainty on radius  $d^2N/dr^2 = -(3/\ln 2) \cdot 1/r^2$  to within a constant is intensity of gravitational field. Thus, spatial uncertainty (information on a particle arrangement in space) defines Newton gravitational potential (the first derivative of uncertainty on radius) and intensity of a gravitational field (the second derivative of uncertainty on radius). It is similarly connected with Coulomb interaction.

**Assertion 2.** *From the time uniformity the law of conservation of energy follows.*

This physical assertion follows from the definition of time uniformity and Noether theorem.

**Assertion 3.** *From space uniformity the law of conservation of an impulse follows.*

This assertion follows from the definition of space uniformity and Noether theorem.

**Assertion 4.** *From space isotropy the law of conservation of the moment of an impulse follows.*

This assertion follows from the definition of space isotropy and Noether theorems.

**Assertion 5.** *From Lagrangian invariance concerning global gauge type transformations  $\varphi' = e^{i\alpha Q} \varphi$  where  $Q$  - a charge of the particle described by field  $\varphi$ , and  $\alpha$  - any number which is not dependent on existential coordinates of a particle, follows the law of conservation of a charge.*

**Assertion 6.** *From Lagrangian invariance concerning local gauge transformations of the type  $\psi'(x) = e^{i\alpha(x)} \psi(x)$ , where  $\alpha(x)$  - generally a matrix depending on existential coordinates, laws of electromagnetic, weak and strong interaction follow. The quantum mechanics is invariant to global gauge transformations  $e^{i\alpha Q}$  and local gauge transformation  $e^{i\alpha(x)}$ . All fundamental interactions are deduced on the basis of gauge invariance. From the point of view of construction of the physical theory, it is an extremely economical and successful scheme.*

**Assertion 7.** *From the law of conservation of uncertainty (information) Gibbs thermodynamic equation (the basic thermodynamic identity) follows.*

Let's assume, that at transition of system from an initial state to the final state the particles are formed (quanta of radiation with zero weight of rest), each of which contains  $I_p = 1$  bit and has energy  $E_p = h\nu$ . Owing to the law of conservation of uncertainty (information) the generated particles should possess information equal to  $\Delta I = I' - I''$ , i.e. should generate  $n = I' - I'' = \Delta I$  radiation quanta. Owing to the law of conservation of energy, the generated quanta of radiation should possess energy  $n h \nu$  equal to  $\Delta U = U'' - U'$ . Thus,  $n h \nu = \Delta U$ . We will consider that the system represents an absolutely black body. Average energy of radiation is connected with the temperature of thermal radiation of an absolutely black body  $E_p = h\nu = 2,7kT$ . As  $n = \Delta I$ ,  $\Delta I \cdot 2,7kT = \Delta U$ , or  $T = \Delta U / 2,7k\Delta I$ . At  $\Delta S = k\Delta I$   $T = \Delta U / 2,7\Delta S$  or  $\Delta U = 2,7T\Delta S$ . In differential kind  $T = dU / 2,7kdI$  or  $dU = 2,7kTdI$ . At  $dS = kdI$   $T = dU / 2,7dS$  or  $dU = 2,7TdS$ . Thus, from the laws of conservation of uncertainty (information) and energy, in that specific case at  $dS = kdI$  Gibbs thermodynamic equation (The expression for the total differential of the internal energy is called the Gibbs equation) follows:  $dU = 2,7TdS$ . Generalization on more general case  $dU = TdS - PdV + \sum_j \mu_j dN_j$  is made by the account of performed job and the

account of addition of particles in system without fulfillment of job and addition in the right part of the corresponding composed. The difference of resulted expression from the standard form of Gibbs thermodynamic equation – the presence in the right part of factor 2,7. Let's assume, that at transition of system from an initial state of particles to the final state of particles (hadrons are baryons and mesons are formed with nonzero mass of rest), each of which contains  $I_p$  bit and has energy  $E_p = m_p c^2 + m_p c^2 / 2$ . Owing to the law of conservation of uncertainty (information) the generated particles should possess the information equal to  $\Delta I = I' - I''$ , i.e. should generate  $n = \Delta I / I_p$  particles. Owing to the law of conservation of energy the generated particles should possess energy  $n E_p = n m_p c^2 + n m_p c^2 / 2$  equal to  $\Delta U = U'' - U'$ . Thus,  $(\Delta I / I_p) m_p c^2 + (\Delta I / I_p) m_p c^2 / 2 = \Delta U$ . We will consider, that each particle has three degrees of freedom. Then  $m_p c^2 / 2 = (3/2)kT$ . As  $(\Delta I / I_p) m_p c^2 + (\Delta I / I_p) m_p c^2 / 2 = \Delta U$ , or  $\Delta U - (\Delta I / I_p) m_p c^2 = (3\Delta I \cdot T / 2I_p)$ . At  $\Delta S = k\Delta I$   $\Delta U - (\Delta I / I_p) m_p c^2 = 3T\Delta S / 2I_p$ . In differential kind  $dU - (dI / I_p) m_p c^2 = 3TdS / 2I_p$ . Thus, from the laws of conservation of



uncertainty (information) and energy, in that specific case at  $dS = kdI$ , Gibbs thermodynamic equation is:  $dU - (dI/I_p)m_p c^2 = 3TdS/2I_p$ . Generalization on more general case  $dU = TdS - PdV + \sum_j \mu_j dN_j$  is made by the account of performed job and the account of addition of particles in system without fulfillment of job and addition in the right part of the corresponding composed. The differences of resulted expression from the standard form of Gibbs thermodynamic equation – the presence in the left part of additional composed  $-(dI/I_p)m_p c^2$  and in the right part of factor  $(3/2)I_p$ . As the law of conservation of energy follows from the law of conservation of uncertainty (information) thermodynamic Gibbs equation follows from the law of conservation of uncertainty (information). From information laws of simplicity of complex systems, conservation of uncertainty (information) follows physical laws of conservation of energy, an impulse, the moment of an impulse, a charge, electromagnetic, weak and strong interaction, Gibbs thermodynamic equation.

**Assertion 8.** *At least six q-bits are necessary for the formation of a fundamental particle.*

### **Information Volume in some Fundamental, Elementary Particles and Atoms**

There is 1 bit in a lepton. There is 1 bit in a quark. One photon with circular polarisation contains 1 bit. □ One photon,  $Z^0$ -bozone - products of electroweak interaction contains 0,78 bits. Elementary particles represent physical systems of the second level of complexity. There are 9,422 bits in a proton, a neutron (taking into account the structure of proton, neutron, the information in quarks, colors of quarks). Atoms represent physical systems of the third level of complexity. There are 11,422 bits in the atom of hydrogen (1st element) - (taking into account the structure of atom, the information in protons, neutrons). There are 39,688 bits in the atom of helium (2nd element). □ There are 109,642 bits in the atom of carbon (6th element). There are 544,21 bits in the atom of iron (26th element). There are 2334,436 bits in the atom of uranium (92nd element). In the above-mentioned cases the structure of atoms and external uncertainty electrons is not considered. The estimates of the joint entropy of matrixes mixture of electroweak interaction (1,7849; 1,7787; 1,7645; 1,7945) according to different independent experimental data, are close to the estimates of the joint entropy of matrixes mixture of quarks (1,7842, 1,7849) [19, 20].

## Estimation of the Volume of Information in Cosmological Objects

Estimation of the volume of information in cosmological objects, including stars of the Sun type, neutron stars, white dwarfs, black holes is necessary for generation of restrictions for their formation, development and interconversion.

Information volume in stars: The Sun contains  $\approx 1,3 \cdot 10^{58}$  bits. The White dwarf with the mass of solar mass contains  $\approx 1,24 \cdot 10^{59}$  bits. □ The Neutron star of solar mass contains  $\approx 2,38 \cdot 10^{59}$  bits. Information volume in black holes: The Plank's black hole contains one nut of information, thereby it is possible to consider nut as one Plank's information unit (one bit is Shannon's information unit). □ Existence of the matter of two types: with square-law and linear dependence of volume of information on mass is the source, reason of existence of the optimal black holes which minimize volume of information in any region of the universe and in the universe as a whole. There are  $\approx 10^{62}$  bits in the optimal black hole generated in the system «radiation (photons) - black hole» at the temperature of radiation - 2,7K. There are  $\approx 2,57 \cdot 10^{38}$  bits in the optimal black hole generated in the system «hydrogen (protons) - black hole». The masses of the optimum black holes shaped of various types of atoms of usual substance or mixture of various types of atoms of usual substance, and information contents in them are approximately identical. The black holes of solar mass contain  $\approx 7,72 \cdot 10^{76}$  bits. The black holes with the mass of one million solar contain  $\approx 7,72 \cdot 10^{94}$  bits. The black holes in centers of galaxies contain  $\approx 10^{90} - 10^{107}$  bits. Information volume in galaxies: In the galaxies having  $10^{11}$  of stars, there are about  $10^{69}$  bits. In the galaxies having  $10^{11}$  of stars and containing in kernels super massive black holes with the mass of  $\approx 10^6 - 10^{10}$  of solar mass, there are  $\approx 10^{99} - 10^{107}$  bits. Information restrictions at creation of black holes from stars: □ The mass of the black hole formed from the star of the sun's type is no more than  $\approx 8 \cdot 10^{20}$  kg. The mass of the black hole formed from the white dwarf of solar mass is no more than  $\approx 2,5 \cdot 10^{21}$  kg. □ The mass of the black hole formed from the neutron star of solar mass is no more than  $\approx 4,17 \cdot 10^{21}$  kg.

Note. The black hole at formation uses only part of mass. Other mass in the form of usual substance dissipates in surrounding space and other objects can be formed of it. Information restrictions at the merge of black holes: □ At the merge of two black holes having the mass  $M_1 M_2$ , without the use of additional usual substance, the mass of the resulting black hole is less than  $\sqrt{M_1^2 + M_2^2}$ . At the merge of two black holes having the mass  $M_1 M_2$ , with the use of additional usual substance, the mass of the resulting black hole is more than  $\sqrt{M_1^2 + M_2^2}$ .

## **Conclusion**

The results presented in this paper show the effectiveness of informational approach for studying physical laws and systems. The works of the author and American, Canadian, European, Chinese, ... scientists are confirming primacy of information laws: information laws (informatics laws) define and restrict physical laws; informatics laws have general, universal character, operate in all possible universes, even in the universes with different physical laws.

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