ABOUT PHYSICAL INFORMATICS

Ursul A.D. predicted in 1968 in his book "The Nature of the information. "The methods of information theory will be studied the properties of space and time than ever before were mainly the physical theory (eg, special and general theories of relativity, Einstein). So, physics and information theory interpenetrate each other, that, in general, leads to the creation of two major synthetic disciplines - the special application of information theory (and most likely, a number of its branches - a thermodynamic and quantum) physics and information.".

The interpenetration of physics and information theory in the development of informatics has formed a synthetic discipline "Physical informatics" [2, 3].

SOME HISTORY

Many eminent scholars have noted the importance of information. J. Wheeler, "My life in physics seems to me to split into three periods. The first of them, stretching from the beginning of my career and the beginning of the 1950s, I was captured by the idea that "Everything - a particle." I was looking for ways to build all the basic elements of matter (neutrons, protons, mesons, etc.) of the lightest, most fundamental particles - electrons and photons. The second time I call the "All - this field". Now I have caught a new idea: "Everything - it's information" (1962); E. Steen (2000) "... identify some of the laws that are similar to the laws of conservation of energy and momentum, but used in relation to the information and determine the most quantum mechanics "; B.B. Kadomtsev (1999): "In going to study increasingly complex systems is the structural and information aspects of their behavior and development of the foreground and the dynamics of creating a framework for Information Development. In view of quantum processes in the microcosm of the world picture becomes even more complex and richer in terms of information behavior. " For the first time an analysis of physical processes using the concepts of information had made by A. Einstein (1905). L. Szilard (1929), analyzing the thought experiment, "Maxwell's demon", has shown that the entropy lost by the gas due to separation of molecules on the slow and fast, exactly equal to the information received, "Maxwell's demon." I. Von Neumann (1932) introduced the notion of quantum entropy. Neumann entropy of a pure state, by definition, is zero, but physicists tend to describe and study of quantum systems using this entropy. Shannon (1948) introduced the concept of information entropy. Information defined by the Shannon entropy in bits (nats) is a universal measure of uncertainty (information) of the classical and the quantum systems.

The systematic application of information theory to the analysis of physical phenomena and processes was apparently first performed Brillouin (1960). "We now introduce a distinction between two kinds of information: 1) free information (free information), occurs when the possible cases are treated as abstract and have no particular physical significance, and 2) the associated information (bound information), occurs when the possible cases can be presented as a microstate of a physical system. " L. Brillouin (1959) showed that a binary unit of information equal to the energy of the Boltzmann constant multiplied by temperature and estimated the amount of information contained in the physical law.

Penrose (1989), Hawking (2005) and others have used information-based approach to the process of formation of black holes. "Can the information to disappear during the formation of a black hole? Where can she go? The black hole swallowed distorts information, but not destroy it completely. During evaporation of the black hole information comes out of her embrace. " A. Zeilinger (1999) put forward the following principle as the foundation of all possible quantum theory, presenting two of his statements: 1) an elementary system represents the truth value of a proposition, and 2) an elementary system carries one bit of information. S. Lloyd (2001) postulated: 1) the theorem Margolis-Levitin, and 2) the total number of bits available for processing in the system is limited by the entropy of the system. 3) The rate of flow of information is limited by the speed of light. These three limits are applied to assess the ability to process information universe. In particular, it is estimated, and the total number of bits available in the universe to compute, and the number of elementary logical operations that can be performed on these bits during the lifetime of the universe. The total number of bits of matter (the result of the author, 1989), S. Hsu and A. Zee (2005), D. Scott and J. Zibin (2005) discuss the problem of representation of the message creator CMB heterogeneities and estimate the volume of messages. They believe that the 10 ^ 5 bits of information can be encoded in the cosmic microwave background.

Gurevich I.M. (1989-present) organizes knowledge in complex systems, information practices on the basis of their research informatics laws and conducts studies of complex systems based on these laws. The main results of the author are: the assertion of the existence of natural laws more general than the physical - the laws of science, defining, limiting physical phenomena and processes, and prior to physical laws, the wording of the laws of science; estimate the volume of information in the universe.

The number of scientists who use the information approach and information methods in physics research, is increasing rapidly. At the beginning of 2010. there are many interesting works, including works by Erik Verlinde. Lee Smolin. N Jarmo Makela. Rong-Gen Caia, Li-Ming Caob, and Nobuyoshi Ohta. Lorenzo Maccone.

DEFINITION OF THE INFORMATION

Along with matter and energy the Universe contains, includes information. Information is an integral part of the Universe. The fundamental principle of quantum mechanics postulates that the elementary physical system carries one bit of information. “Information is heterogeneity, stable for some definite time”. Regardless of the nature of heterogeneity, would be it letters, words, phrases or - elementary particles, atoms, molecules, or - people, groups, societies, etc. "By information we mean a stable some time heterogeneity arbitrary physical nature. Thus, the character in the book, atom, molecule, an elementary particle, the star, drawing, painting, plowed fields, woods and other heterogeneities contain and carry the information. "Classes heterogeneities: physical, chemical, biological, geological, technical, social, economic [18].

The measure of the degree of heterogeneity or information is Shannon's information entropy (entropy, by definition, Neumann can not be used as a measure of heterogeneity, since it is zero for a pure state has a structure) and other information characteristics (information divergence, joint entropy, mutual information).

This leads to the use of information research methods as the information itself, and its related matter and energy. This approach provides a new and sometimes more general results with respect to the results obtained on the basis of only physical laws.

Ursul A.D. in 1968 in his book "The Nature of the information. Philosophical essay "[1] gave a close to the above definition of information:" ... first of all, the information related to diversity, difference, and secondly, with reflection. Accordingly, it can be determined in the general case, as reflected by the diversity. Information - this variety, which contains one object for another object (in their interaction) ... But the information can be viewed as diversity is the result of reflection as to the object itself, that is self-reflection. ... Information is a property of matter, which is universal ... The concept of information reflecting both objectively real, independent of the subject property is inanimate and animate nature, society, and the properties of knowledge and thinking ... The information in this way, inherent in both material and ideal . It is also applicable to the characterization of matter, and the characterization of consciousness. If the objective information can be considered property of matter, the ideal, subjective information is a reflection of the objective, material information" "V.M. Glushkov in a number of characteristic information as a measure of heterogeneity in the distribution of energy (or matter) in space and time ... there is information to the extent that there are material bodies, and therefore he created heterogeneity". Interestingly, in his book Ursul A.D. noted that "heterogeneity - is another expression of the form diversity."

Let us clarify the definitions of information and informatics [30] "Information - is stable some time diversity (heterogeneity) of any physical nature (animate and inanimate matter, society, mind), described and studied all the applied sciences, which has a number of properties, primarily a reflection. Informatics - the science of information. The subject area of informatics: Natural systems (living and nonliving), a system created by civilization, including the social and economic systems. Methods: Evaluation of information system characteristics. Assessment of other characteristics of the systems related to information systems, data characteristics (information on the characteristics). The study of information laws (in specific subject areas and general). There is no one definition of science, which would not be a special case of this definition. This definition can not affect, limit anyone's research interests, can not cancel, deny any known or future directions of research."

PHYSICAL INFORMATICS. MAIN RESULTS

Physical Informatics is the science that studies by the information methods of physical systems. This discipline is created, mainly in the works of Gurevich IM [18-23]. It is shown that information together with the laws of the physical laws can be an effective tool for understanding natural systems and the Universe as a whole.

The relationship between physical and information characteristics of physical systems - mass, energy, entropy and information makes it possible to use information research methods assessing the physical characteristics of systems. Information laws (the laws of informatics) are universal, operate in all possible universes. The main characteristics of heterogeneities (information) of physical systems are: uncertainty (information) and information divergence observed (observable in quantum mechanics called any physical quantity that can be measured, and the results of the experiment must be real numbers) and states (the state of a physical system defined by the vector in a Hilbert space), which characterizes the amount of information (information capacity) of the heterogeneity; joint information entropy, which characterizes the unitary transformation; mutual information, which characterizes the interaction of physical systems; differential information content of matter. Among the results obtained by Gurevich IM [18-23] It should be noted that:

Information is physical heterogeneity. The information characteristics of heterogeneity are: Shannon's information entropy, information divergence, joint entropy, and communication information. The informatics laws of nature are: the law of simplicity of complex systems, the law of uncertainty (information) conservation, the law of finiteness of complex systems characteristics, the law of necessary variety by Ashby W. (1956), and the theorem of Gödel K. (1931). The main principle of quantum mechanics by Zeilinger (1999) is: elemental physical systems contain (carry) one bit of information. The law of finiteness of complex systems characteristics and the principle of necessary variety by Ashby impose restrictions on the topology and symmetry of the universe; time is one-dimensional Euclidean space. Space is three-dimensional Euclidean space. Time is homogeneous. Space is homogeneous. Space is isotropic. Space is flat. The universe is four-dimensional pseudo-Euclidean space. The law of simplicity of complex systems and the law of uncertainty (information) conservation impose restrictions on physical transformations of the space-time and transformation of internal symmetry: Jacobian transformations are equal to 1. Transformations are linear. Equality to one of the determinants of linear transformation defines that, among the space-time transformations, only translations and owns rotations are physically possible. I Irreversibility of time, not the owns rotations, reflexions are forbidden and physically cannot be possible because Jacobians transformations are equal to - 1. (1989). Equality to one of the determinants of linear transformation defines that, among transformations of the internal symmetry, only unimodular transformations are physically possible. Restrictions on symmetry of space-time define physical laws of conservation. The homogeneity of time defines the law of energy conservation. The homogeneity of space defines the law of impulse conservation. Isotropic spaces define the law of conservation of impulse momentum. The principle of field interaction imposes restrictions on interaction process; the interaction of particles is carried out through corresponding fields. A particle does not need to know interaction laws—it must feel a field. The law of simplicity of complex systems and the law of information conservation allow the selection of the most simple models to adequately describe the universe: the universe is identical to metagalaxy; the universe is a homogeneous object; the universe is an isotropic object; the universe is a flat object. Increase in the scale factor of inflationary expansion of the universe is $\approx 10^{45}$ times.

• The procedure for estimating the information volume in physical objects consisted of the following. At first, the volume of information in the lower level objects – the fundamental particles (leptons and quarks) was estimated. According to Zeilinger's (1999) principle, we considered that, in the lower level objects, one bit of information was contained. Further, the volume of information in the objects of the second level was estimated. It was equal to the total of the information volume of objects of lower level plus the volume of information contained in the structure of objects of the second level of the hierarchy (mesons, baryons). The volume of information in the structure of objects of the second level is estimated on a wave function of the objects of the second level. The volume of information in objects of additional levels is similarly estimated.

Direct estimates of the information content in physical systems (fundamental and elementary particles, atoms, molecules, ..., (2007-2009).

•Existence of several types of substance with different dependence of information content I on mass M (including linear for usual substance and for dark substance $I \propto M$, square for black holes $I \propto M^2$, linearly-logarithmic for neutron stars and white dwarfs $I \propto M \log_2 M$, zero for dark energy $I \equiv 0$) was disclosed (2007, 2009).

•Consumption of energy (mass) for the creation of microinformation and classical information (remembered, played back) for different types of matter was determined. In the standard model of the universe, the expansion of the mass of usual substance decreases.

•In the expansion of the universe with acceleration, the mass of usual substance in the beginning decreases, reaches a minimum, and then increases (2007c).

• It is shown that the space uncertainty (information) on the particle layout in space spots the Newtonian gravitational potential (the first derivative of information on radius) and the strength of gravitational field (the second derivative of the information on radius): the type of gravitational potential is $\propto 1/r$ the type of strength of gravitational field is $\propto 1/r^2$ (2008, 2009). The same is true for the Coulomb interaction potential and the field intensity strength of the Coulomb interaction.

• It is shown that the irreversibility of time (1989).

• It is shown that the laws of informatics determine the effect of physical conservation laws (energy, momentum, angular momentum).

• Developed information models of cosmological objects (black holes, neutron stars, white dwarfs, solar-type stars) (2007-2009).

• The Hawking's formula for black holes (the information emission spectrum) (2007).

• The formula for the information emission spectrum of neutron stars and white dwarfs (2009).

• The method and give estimates of the volume of information in stars like the Sun, neutron stars, white dwarfs, black holes and other cosmological objects (2007-2009).

• The information limitations on forming and merging black holes were received (2009).

• Open and investigated the existence of optimal characteristics of black holes (minimizing the volume of information in the Universe, the Universe as a whole) (2007).

• The existence of initial discontinuities of the universe (with the use of information divergence) was proven. The estimates of the initial discontinuities mass of the universe were given (2009).

• Expansion of the universe from initial heterogeneity generates new heterogeneity (information). The universe expansion is the reason and source of information formation. Various physical processes in the extending universe form information (1989-2009).

• It was shown that the phase transformation generates information (2009).

• The curvature of the universe also generates heterogeneity (information).

• It was shown (2010) that the volume of information, shaped in a frame of reference, moving with acceleration, is equal to $I = -\log_2 J = -\log_2 \sqrt{1 - ax/c^2} \approx ax/c^2$. J-jacobian, a-acceleration, x-coordinate, c- speed of light. We will pay attention to the analogy to the effect Unru. The appearance of thermal radiation in an accelerated frame of reference in the absence of this radiation in a counting inertial system is the appearance of additional information in an accelerated frame of reference in the absence of this information in a counting inertial system.

• Estimates of the maximum and minimum possible, the current volumes of information in the universe, the basic estimates of information characteristics of the universe (1989 - 2009).

• It was shown that, to four known types of interaction (gravitational, electromagnetic, strong, and weak); one should add one more type of interaction - information interaction (2007).

• The estimated joint entropy for various independent experimental data characterizing the mixing matrix of the electroweak interaction (1.7849, 1.7787, 1.7645, 1.7945) are close to estimates of the joint entropy of the quark mixing matrix (1.7842, 1.7849 .) This indicates common information and the physical nature of the strong and electroweak interactions.

• It is shown that physical systems can be represented as a direct sum of direct products of q-bits, and for the formation of fundamental particles must be at least 6 q-bits.

• Obtain fundamental limitations on memory capacity and performance of information systems. Estimates of the volume of information in the atoms, nitrogen bases, amino acids, the differential information content of ordinary matter define the fundamental limits on information storage capacity. Structure and energy difference or the activation energy of the basis states of a hydrogen atom, considered as a qubit, impose fundamental limitations speed computing devices. These limitations on memory capacity and performance of information systems can be added to a number of fundamental natural constraints, including the speed of light, the elementary charge, Planck time, ...

• From the information point of view, the necessity of a physical systems description (quantum mechanics) by means of nonclassical probabilistic logic was defined (2009).

• It was shown that, in all possible universes, the informatics laws and likewise physical conservation laws operate (2009).

In papers Lisi A. Garret; Erik Verlinde; Lee Smolin; N Jarmo Makela et al:

• based on the principle of maximum entropy, the need probabilistic description of physical systems (quantum mechanics) (2006),

• Information from the assumptions is defined:

The law of gravitation (2009-2010),

Newton's second law (2009-2010),

Friedmann equation (2010),

• shows the irreversibility of time (2009).

Gurevich I.M. and foreign scientists (American, Canadian, European, Chinese ...) confirm the primacy of information laws.

• Information laws (the laws of science) define and limit the laws of physics.

• The above information shows that the priority of obtaining information by methods of the physical results belongs to Russia, although the recent results of international scientists are very interesting and important.

• Use of information laws (laws of science) in conjunction with physical laws to reveal all the secrets of nature, in particular, to construct a theory of quantum gravity.

CURRENT PROBLEMS OF PHYSICAL INFORMATICS

Taking into account the received results we list the current problems of physical informatics.

1. Development of information research methods of physical systems - physical informatics.
2. Evaluation of information characteristics (information entropy, information divergence, a joint information entropy, imutual information and differential information capacity) of physical, chemical and biological systems.
3. Estimates of the amount of information in physical, chemical and biological systems.
4. Derivation from the laws of informatics physical laws.
5. Joint application of energy conservation law and uncertainty (information) conservation law for calculate the characteristics of physical systems and processes.
6. The study of information interaction of physical systems.
7. Formation of information restrictions on the formation, development, interconversion of physical, chemical and biological systems.
8. The study of information characteristics of quantum computers and quantum computing.
9. Formation of the fundamental constraints on the characteristics of information systems.
10. Estimation the volume of information that defines the appearance and development of the universe. Estimation of heterogeneities mass containing this information.
11. Study the universe's expansion as the causes and sources of forming information in the universe.
12. Formation constraints on the control of the universe.
13. Formation of restrictions on the cognition of the universe.
14. The study of methods of forming the classical (memorized, copied) information in the universe.
15. Analysis of information characteristics of extraterrestrial civilizations.
16. Determination of the minimal cognition subject.
17. Study on a compact representation of knowledge and conservation the accumulated knowledge of civilization.

18. Development of information bases of the theory of quantum gravity, "Theory of Everything."

MAIN SOURCES

1. *Ursul A.D.* The nature of the information. Philosophical essay. Politizdat. M. 1968. – 288 p.
2. *Kolin K.K.* The evolution of informatics. Information Technologies, № 1, 2005. Pp. 2-16.
3. *Gurevich I.M.* Introduction to physical science. The collection Scientific Session of IPI RAN. M. 2005.
4. *Wheeler J.* «Geons, Black Holes & Quantum Foam: A Life in Physics». New York, W.W. Norton & Company, 1998, pp. 63-64.
5. *Steen E.,* "Quantum computing". Moscow-Izhevsk. Research and Publishing Center "Regular and Chaotic Dynamics." 2000. 112.
6. *Kadomtsev B.B*. Dynamics and Information. Moscow. The editors of the journal Advances in physical sciences. 1999. 396 c.
7. *Einstein A.* On the electrodynamics of moving bodies. Collected Works. V.1. Moscow. Science. 1965. ss. 7-35.
8. *Szillard L.* Physik. 1929. V. 53. P. 840.
9. *Neumann D.* Mathematical Foundations of Quantum Mechanics. Moscow. "Science", 1964. With 366.
10. *Shannon C.* Mathematical Theory of Communication. Work on information theory and cybernetics. Foreign Literature Publishing House, Moscow. 1963 cc. 243 - 332.
11. *Brillouin L.* Science and Information Theory. State publishing of physical and mathematical literature. Moscow. 1960. 392.
12. *Penrose R.* The new king mind. Moscow. URSS. 2003. (Oxford University Press. 1989). 384.
13. *Hawking S.W., Penrose R.* The Nature of Space and Time. Izhevsk. NIC "Regular and Chaotic Dynamics." 2000. 160.
14. *Zeilinger A.* A Foundational Principle for Quantum Mechanics ", Foundations of Physics 29 (4): 631-643. (1999).
15. *Lloyd S.* Computational capacity of the universe. arXiv: quant-ph/0110141 v1 24 Oct 2001.
16. *Hsu1 S., and Zee A.* Message in the Sky. arXiv: physics/0510102 v2 6 Dec 2005.
17. *Scott D. and Zibin J.* The Real Message in the Sky. arXiv: physics/0511135 v1 15 Nov 2005.
18. *Gurevich* I.M. Introduction to physical informatics. Sat Scientific Session of IPI RAN. M. 2005. Gurevich I.M. The laws of informatics - the basis of research and design of complex communications and control systems. Manual. - Moscow: TSOONTI "Ecos", 1989. 60 p.Gurevich I.M. "The laws of informatics - the basis of the structure and knowledge of complex systems." - M. "Antiqua", 2003.
19. *Gurevich I.M.* "The laws of science - the basis of the structure and knowledge of complex systems." Second edition refined and updated. M. «Антиква». 2003. 176 c.
20. *Gurevich I.M.* "The laws of science - the basis of the structure and knowledge of complex systems." Second edition refined and updated. M. "Torus Press." 2007. 400.
21. *Gurevich I.M.* Estimation of the main information characteristics of the Universe. Information Technology. № 12. The application. 2008. 32 p.
22. *Gurevich* I.M. Information characteristics of physical systems. "The 11th FORMAT". Moscow. "Cypress". Sevastopol. 2009. 170.
23. *Gurevich* I.M. Information characteristics of physical systems. Second edition refined and updated. "Cypress". Sevastopol. 2010. 260.
24. *Lisi A. Garrett.* Quantum mechanics from a universal action reservoir. arXiv:physics/0605068v1 [physics.pop-ph] 8 May 2006.
25. *Verlinde E.* On the Origin of Gravity and the Laws of Newton. arXiv:1001.0785v1 [hep-th] 6 Jan 2010. Institute for Theoretical Physics University of Amsterdam/ Valckenierstraat 65. 1018 XE, Amsterdam. The Netherlands.
26. *Smolin L.* Newtonian gravity in loop quantum gravity. 1001.3668v1 [gr-qc] 20 Jan 2010. Perimeter Institute for Theoretical Physics, 31 Caroline Street North, Waterloo, Ontario N2J 2Y5, Canada. January 21, 2010.

27. *Makela J.* Notes Concerning ”On the Origin of Gravity and the Laws of Newton” by E. Verlinde. 1001.3808v1 [gr-qc] 21 Jan 2010. Vaasa University of Applied Sciences, Wolffintie 30, 65200 Vaasa, Finland.
28. *Rong-Gen Caia, Li-Ming Caob, and Nobuyoshi Ohta*. Friedmann Equations from Entropic Force. arXiv:1001.3470v1 [hep-th] 20 Jan 2010. Key Laboratory of Frontiers in Theoretical Physics, Institute of Theoretical Physics, Chinese Academy of Sciences, P.O. Box 2735, Beijing 100190, China Department of Physics, Kinki University, Higashi-Osaka, Osaka 577-8502, Japan.
29. *Maccone L*. A quantum solution to the arrow-of-time dilemma. arXiv:0802.0438v3 [quant-ph] 25 Aug 2009. QUIT, Dip. A. Volta, 27100 Pavia, and Institute for Scientific Interchange, 10133 Torino, Italy.
30. *Gurevich I.M., Ursul A.D.* Information - the general property of matter. Characteristics. Estimates. Restrictions. Consequences. URSS. (Book in press).