INFORMATION IN THE STRUCTURE OF THE UNIVERSE

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In the beginning was the Word.
Gospel of John

Concept of "information" is widely used in modern science; Latin "informatio" literally means "data" or "message".

No scientist who dealt with basic studies of information could discover physical essence of this concept.

Appearance of information theory was induced by development of technical communication systems which had to ensure information exchange. I'd like to emphasize – technical systems, operation principles of which are determined by physics laws, i.e. laws of material world. Optimization of such systems operation required first of all dealing with amount of information which can be transmitted via communication channels. That is why it is natural that first steps in this field were fulfilled by employees of Bell Telephone Companie – H. Nyquist, R. Hartley and C. Shannon. Later on results of these works formed a basis for Shannon's calculation of communication channels data throughput, improving of messages coding and decoding methods and solving of other questions related to optimization of technical communication systems operation. Collection of these notions, called by Shannon "mathematical theory of communication", became a basis of classic Information theory. However in Shannon's works explanation of information physics was missing; substitution of "information" and "amount of information" concepts happened. Shannon's Information theory did not answer to "What is information?" question; it only answered to "What amount of information may be transmitted in time unit using a set certain signals?" question. It should be understood clearly that without revealing of "information" concept's physical

V.I. Nesterov

essence and at the same time naming frequency characteristic of code letters by "amount of information" term, Shannon created a possibility for identification of two absolutely different in their nature phenomena: information as a physical category and information as frequency of a certain message happening.

Norbert Wiener – father of cybernetics or "science of control and communication in the animal and the ma-

chine" – also had no clear idea about physical essence of information. "Information is information, not matter or energy, it is something else", – he wrote.

French physicist L. Brillouin noticed that Shannon's formula for information amount calculation is similar in its structure to formula offered by Boltzmann, which is used for entropy amount calculation. Concept of messages entropy allowed Brillouin to postulate "omnipresence" of information and assume that measure of information amount, related to a certain object, may be a complexity of its internal structure. Abovementioned postulates and their consequences are given by L. Brillouin in his studies in details. Brillouin took the following value as the universal measure of information amount:

$$I = k \cdot ln\, p, \text{ where}$$

p – a "complexity" of a certain object's structure; k – a constant depending on chosen system of measure units; ln – a natural logarithm.

This formula resembles Boltzmann's formula for entropy amount calculation:

$$S = k \cdot ln\, W, \text{ where}$$

S – entropy, k – Boltzmann constant, W – thermodynamic probability.

Hence appears one important circumstance: when we lose information we increase entropy of a system, in other words – we decrease level of its internal structural organization.

Thereby,

$$I + S = const$$

as a consequence of the second law of thermodynamics – entropy of a closed system is a constant value and it cannot decrease with time.

In the 60's of the last century thanks to L. Brillouin "negentropy principle of information" appeared and became widely known. Differing from entropy, regarded as irregularity measure of a certain system, negentropy usually means measure of order or structural "complexity" of surrounding system related to various entropic processes in physical world. Brillouin offered to express information I and entropy S in the same units – informational (bits) or entropic (erg/degree).

B. Kadomtsev notes that values I and S are formally equal because I corresponds to information of one single state of many possible states, S is defined by multitude of all states.

In modified in accordance with modern ideas Information theory information is regarded from the point of view of physical statistics as a certain mathematical abstraction, a measure of algorithmic state of chaos. Information theory describes principal laws of information exchange, but it does not reveal its physics.

Quantum-entropic logic theory became a theory regarding information as a material category revealing physical essence of entropic-information interactions and describing interaction of mass, energy and information within a system.

Quantum-entropic logic theory postulates:

1. Information is a material category, just like energy and mass of a system.

2. Due to the fact that information is material it follows the conservation law. Information cannot disappear without a trace or appear from nowhere. Total amount of information in a closed system (a system which does not exchange mass, energy and information with environment) – is a constant value.

It should be noted that Quantum-entropic logic theory deals with negentropic properties of information only. Object of this branch of learning is something poorly resembling what we call information in everyday life. Indeed, in everyday life semantic, intensional aspect of information prevails, but Quantum-entropic logic theory does not consider semantics of information at all.

In 1923 duke Louis de Broglie, a young French nobleman, assumed that wave properties are typical not only for light but for matter also. His arguments were that Einstein's equation

$$E = mc^2$$

(c – speed of light in vacuum) links mass with energy, but on the other hand Einstein and Planck linked energy and wave frequency. Combining these two principles one may conclude that mass should have wave incarnation also.

Quantum-entropic logic theory expands de Broglie conclusions to all material mediums, including information. It shows that all matter display wave properties.

Quantum-entropic logic theory offered a formula for information wave radiation quantum which links in with energy of a system through Planck constant.

Formula:

$$I = \frac{E}{\sqrt{h}}$$

(h – Planck constant) links energy of any material system with level of its complexity, in other words, with level of its structural organization. Level of complexity (structural organization) is the same essential quality of any material system as mass and energy of this system. Information has even more universal character than mass, because a number of fundamen-

tal particles, such as photon, have no mass at all. But all material objects, with no exceptions, have more or less complex structure, that is why we probably should speak not about quantum-wave dualism (where "wave" term means force fields only), but about triunity in description of material world, when information is included into equation together with mass and energy as a full member.

Electron interference phenomenon discovered by Davisson and Germer demonstrated in reality that electrons are similar to waves. Austrian physicist Erwin Schrödinger assumed that these waves are electrons "spread" along space. But this concept was too inaccurate. How can "spread" electron be in several places at the same time? It complicated interpretation of what "spread" electron really is.

In 1926 German physicist Max Born suggested his own interpretation of electronic wave. Born's theory relates to one of the most strange and incomprehensible, from the point of view of human logic, property of quantum theory. Nevertheless it is proven by great amount of experimental data. According to this theory electronic wave must be interpreted from the point of view of statistical probability. But rightful question arises: "How can probability function, a certain mathematical abstraction govern electron behavior, as if it is real physical field?" Here lies obvious logic disagreement. Statistical probability, from the classic physics standpoint, is non-material category and it cannot be related to implementation of fundamental laws of physics. As Einstein said about it: "He (God) does not play dice". Any physical theory, even if it is mathematically flawless, must have internal noncontradictory logical structure. Supporters of quantum mechanics, in their try to fix logical disagreement, say that probability in quantum-mechanical calculation have higher fundamentality than roulette has. But it is still unclear what this higher fundamentality consist of? Probably wave function would get even higher fundamentality in one case only: if it could be regarded as a physical field. What is probability according to Information theory – it corresponds to information (I) of one state out of many possible states. Hereby terms "probalbility" and "information" may be unified in this context. From the point of view of Quantum-entropic logic theory information is a material substance, a physical field directly linked to energy and mass of an object.

Thus application of Quantum-entropic logic theory postulates may eliminate severe logical contradictions existing in quantum mechanics.

One of properties of information fields, which follows from quantum mechanics postulates, is that information fields must be transferred by some class of microparticles, just like electromagnetic forces, at the level of fundamental particles, are transferred by photons. In physics there is a tradition to call interaction fields particles with names with "-on" endings, such as "photon", "gluon", etc. that is why fundamental particle of information-entropy exchange was also called "informon". So infomons are the most fundamental quantum beam of information. Although infomons are still to be experimentally proven (if it is even possible someday), one can say with certainty that infomons must have the following properties: they must have no mass; they must have negligibly and vanishingly small, but not zero, interaction energy and have spin 2.

What is spin of a particle? Spin is a quantum-mechanical term corresponding to moment of momentum in classic mechanics. Fundamental particles have "inherent" number of spin, equal to integral or half-integral number (in Planck constant units), which never changes.

All known particles in the Universe may be divided into several groups: particles with spin 1/2, which form matter of the Universe; particles with spin 1, which create forces acting between particles of matter – photons, weak gauge bosons and gluons. Infomon must have double spin of photons, gauge bosons or gluons, i.e. spin 2, in order to transfer information-entropic interaction.

Superstring theory starts with suggestion about what is the lesser indivisible component of matter. For many decades generally accepted answer was that matter consists of particles – electrons and quarks – which are positioned as point which cannot be divided and have no size and internal structure. Conventional theory stated and experiments proved that these particles are connected by various means, forming protons, neutrons and vast variety of atoms and molecules, forming everything around us.

Superstring theory offers another picture. It does not deny principal role of electrons, quarks and other particles, but it states that these particles are not points.

For the first time Superstring theory was formulated in 1968 by Gabriele Veneziano, young Italian physicist who worked in CERN and studied strong nuclear interactions. Leonard Susskind of Stanford University, Holger Nielsen of Niels Bohr Institute and Yoichiro Nambu of Chicago University have offered physical justification of Veneziano's discovery. These scientists have shown that interaction between particles happens due to smallest, extremely thin, almost rubber-like fibers of energy, few hundreds billions times thinner than separate atoms of nucleus. These small elastic fibers were called strings. And just like guitar strings vibrate in various ways, each of which creates different chords, superstrings may also oscillate in various ways. But these oscillations do not produce various music notes; Superstring theory says

that they produce various properties of particles. Tiny string vibrating in a certain way will have mass and electron charge. In accordance with the theory such vibrating string is something we use to call electron. String vibrating in other way will have all required properties to identify it as quark, neutrino or any other kind of particles.

All families of particles are unified in Superstring theory, because each of them appear from various vibrating states (mods) done by one and the same basic object – superstring.

Information fields' properties analysis allowed making a conclusion that in spite of the fact that Superstring theory was discovered in attempt to understand strong interactions, it is actually may be resolution of another problem also. It may be quantum-mechanical theory of information-entropy interaction. Such conclusion is possible because in strings oscillation spectrum John Schwarz and Joel Scherk have found a mod corresponding to zero-mass particle with interaction energy value about a zero and spin 2. Presumably these characteristics are distinctive features of informon. Thus string theory equation contains quantum-mechanical description of information fields.

The only parameter necessary for strings calibration is their tension. How to define this tension? If we could touch a superstring we would know its hardness and would define tension just like we do it with guitar or another string instrument. But because fundamental strings are so small we cannot use this method and we face a necessity to develop an indirect method.

Schwarz and Scherk have developed an indirect method of strings tension defining used in Superstring theory in 1974. Their calculation showed that intensity of interaction transferred by string oscillation in accordance to fundamental particle is inversely proportional to a string tension. And as soon as informon transfers vanishingly small interaction, obtained value of tension must be enormous, about 1039 tons – value of so-called Planck tension.

When guitar strings are fastened, which guarantees constancy of their length, superstrings have no such fastening limiting their length. Instead of it, enormous tension of informon string will force loops, which are examined by strings theory, squeeze to submicroscopic size. Under Planck tension, with participating sub-Planck fluctuations, informon string may be squeezed to a size lesser than Planck length, i.e. lesser than 10-33 cm. Thanks to such great tension energy of informon string oscillating loop becomes truly gigantic in comparison with usual scale of fundamental particles physics, millions and millions times higher than electron string energy.

According to modern conception of quantum mechanics, there is no such thing as distance shorter than Planck length and time span lesser than Planck time (10-43 seconds). If concept of informon fields is correct it means that existing concepts of space and time – system in which quantum mechanics operates, turns out to be incomplete and applicable in particular cases only. Involvement of informons fields theory consists in the following: space and time do not lose their meaning in extremely small scales, lesser than Procrustean bed of Planck length, instead of that they modify into another, more fundamental concepts. Decreasing below Planck scale becomes possible because concepts of space and time continue in form of other and more universal notions.

If we look at distances scale within Planck length we will see that quantum-mechanical fluctuations of transforming informon field are so substantial and may cause so strong and uneven inflation of space that it can turn into foamed, turbulent and swollen form. John Wheeler offered term "quantum foam" to designate a state discovered during studies of ultramicroscopic space and time in scales lesser than Planck length. In this "quantum foam" terms of classic physics such as "farther" and "closer", "in front" and "behind" (even "before" and "after") become fuzzy and vague.

Basic principles of general theory of relativity and quantum mechanics allow defining of approximate scale of distances, passing to which turns off laws of existing physics and turns on other quantum-entropic logics. Smallness of Planck constant and vanishingly small value of information-entropy interaction force has negligibly small size, about 10-33 cm. Here is an example to illustrate this size: if we scale up size of atom to a size of the Universe, Planck length in this case will be equal to height of two-storied building.

There is a concept of phase states in physics. In general case phase relates to possible descriptions of physical system at changing of its parameters on which this system depends (for example, temperature, string tie constant, type of space, time, etc.).

In respect to a matter phase state means one of possible states of the matter: solid, liquid and gaseous. We take ice as an example. If you increase its temperature above 0 degrees Celsius, solid ice will melt down and eventually turn into water. Ice is a rock-solid state, water is viscous liquid. Simple observations show no evident signs that their molecular composition is identical – H2O. If you continue to heat up water, in some period of time, when temperature of water reaches 100 degrees Celsius, another transformation will happen: liquid water starts to boil and turn into steam, which in its turn does not resemble water and ice in appearance at all. Although of course all three substances have the same molecular composition. Changes from solid to liquid and from liquid to gaseous are known as phase transitions.

So many words about ice, water and steam and their phase transitions – how can it be related to matter and information? Quantum-entropic logic theory states that not only a substance may be subjected to phase transition, but all matter also may. There are grounds to be sure that when matter goes through specific critical states, similar to 100 degrees Celsius for steam and 0 degrees Celsius for water, it is also subjected to radical extensive transformation.

Substance may be conventionally represented as "frozen part" of matter. When a particle of a substance reaches speed close to speed of light in vacuum (300 thousand kilometers per hour) it starts to "melt" and turns into energy. Therefore force fields may be rendered as "liquid" part of matter. When size and energy of a particle decreases down to Planck values energy starts to "boil" and transform into information. Thus information field may be represented as "gaseous" part of matter.

Big bang theory is the basic theory of space origin. This theory describes evolution of space from split second after something had happened to the existence of the Universe, but it does not say a word about time zero. Big bang theory does not cover the bang itself. It says nothing about what had exploded, why it had exploded, how exactly it had exploded and, frankly speaking, had there been an explosion at all? The Big bang is a totally mysterious phenomenon. What could be that outside directed force which started the expansion of the Universe? Certain types of strong repulsive forces must have played a crucial role in the bang, but what natural forces could it be? For many decades this most important of all cosmological questions remains unanswered. And only in 2000s was made a suggestion that this force could be transforming informon field. During time span, in comparison with which nanosecond might seem eternal, early Universe provided a scene where information displayed its repulsive properties, dragging one region of space from another with inexorable force. Repulsive effect of transforming informon field was so strong that it not only engaged the bang, but revealed something which forces the Universe to expand for already 14 billion years until the present day. In theory, which operates information field, early Universe expanded with overwhelming gigantic coefficient, in comparison with standard Big bang theory, thus enlarging our cosmological perspective to the degree when we understand that our galaxy is the one among hundreds of billions galaxies.

The Big Bang

The "Information bang" theory offers the most important modifications of standard Big bang theory propositions, gives an idea about events which happened at point zero and in the earliest moments of the Universe existence. This theory gives answers to key questions lying beyond standard model of the Big bang theory, makes a number of predictions which find experimental proofs.

These questions which could not be answered by standard Big bang theory:

1) Where all this mass and energy filling the Universe came from?

2) What causes inflation of space and matter?

were successfully redirected to Theory of extensive transformation of information into substance and energy.

But even in this situation some fundamental basics remain unclear:

- Was there a time before the Information bang and if yes, what was it like?

- What caused informon field to initiate the Information bang?

These questions remain unanswered and still wait for their discoverers. They are part of urgent scientific matters that move forward cosmological studies and remind us about many tangled knots, which we have to untangle before we say that we completely understand structure of the Universe.

Some brand new aspects in understanding of space expansion from the point of view of informon field's universal effect in any scales of matter structural organization are worthy of mentioning separately.

Until the present days the Universe expansion is regarded by many scientists only in mechanistic way, as recession of galaxies, without involvement of other astronomical and physical objects of lesser sizes. Theory of extensive transformation of information into substance and energy regards the Universe expansion as global and universal process, involving space with all contained in it material objects at any

Receding galaxies

distances from the Universe down to separate quantum of matter.

From this point of view, if space expands it should mean that in addition to recession of galaxies, inflating space within a certain galaxy will move all its stars away from each other, in its turn inflating space inside every star or planet or inside us or inside anything will move all constituent atoms away from each other, and inside atoms – electrons, protons and neutrons and deeper and deeper down to the smallest components of matter. So because all tissue of space expands, all basic physical constants will expand proportionally. Space will force every thing, including our measuring bars, increase its size and that is why it is impossible in the essence to recognize that some expansion really happens.

Relying on special theory of relativity Einstein proclaimed that gravitation and acceleration are absolutely identical. Accelerated observer, according to Einstein, warps space just like gravitation does. Moreover Einstein proved that in general gravitation and acceleration are indistinguishable.

There is scientific methodological principle, named after philosopher-nominalist William of Ockham, saying in simplified way: "Entities must not be multiplied beyond necessity".

Following this principle, if all problems related to time-space warping may be solved from acceleration standpoint only, it means that absolutely similar and identical to them effects related to gravitation, in the final analysis may be brought to accelerated movement, not involving such category as gravitation. In other words gravitation may be "cancelled" due to uselessness.

There is no doubt that gravitation is the basic physical category underlying modern physics including general and special theories of relativity. Any attempt to discard it will be interpreted as madness rather than manifestation of scientific courage. But is this idea crazy enough to be true?

All abovementioned requires more detailed explanation and we will try to present it.

Theory of extensive transformation of information into substance and energy says that space expansion provides extension of any physical body included in tissue of space. Thus Sun, Earth and other astronomic objects, usually considered to be as stationary ones, in fact extend, inflating from inside as balloons. If we could prove that astronomical objects, including stars and planets, not only extend, but extend with acceleration, in this case using principle of acceleration and gravitation equivalence, gravity effect may be brought to accelerating extension of astronomical body. I.e. accelerating extension may completely imitate gravitational attraction.

Thus whole question, in general, is to define if Universe extends with or without acceleration now?

Two groups of astronomers – one under guidance of Saul Perlmutter in Lawrence Berkeley National Laboratory, another under guidance of Brian P. Schmidt in Australian National University – have proved fact of accelerating expansion of the Universe by measuring of remote supernovas speed in the 90's of the last century. Thanks to innovative technology of simultaneous observation of thousands of galaxies via wide-angle telescope, these teams were able to find about four dozens of supernovas at various distances from Earth. After careful calculation of distance and velocity of recession both groups came to unequivocal conclusion: speed of the Universe extension increases, i.e. space expands with acceleration. Researchers of supernovas concluded that observed accelerated expanding requires directed outside repulsion of cosmological constant, function of which may be fulfilled by transforming informon field. Informon field may play role of a force imitating gravitation at phenomenon of astronomical objects accelerated expansion.

Thus when you drop a glass, it is not gravitation field that attracts it to Earth, but expanding Earth bumps into the glass.

Paraphrasing well known Einstein's quote we may say that Quantum-entropic logic theory is too elegant to be wrong. It is characterized by inner logical consistence; it does not contain inner logical absurdity. It is the case when beauty and elegancy of one or another physical theory corresponds to beauty and elegancy of surrounding world.

Of course there is no assurance that such considerations will lead us to the truth. Nevertheless all

the time, especially now as we enter an era when our theories describe fields which cannot be experimentally studied, physicists will count on such aesthetic consideration that may help to avoid dead ends. Until now such approach demonstrated its strength and forecasting power many times.

Quantum-entropic logic theory is not a modest theory. Its objectives and promises are great and it is exciting and praiseworthy, because if a theory claims to be a theory of the Universe, it must be equal to the real world not only in approximate draft, but in every small detail also.

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