# Research on the Increase of Information Theory in the Era of the Ending of Silicon Electronics and New Types of Risks

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## Abstract

Today, it is obvious that the era of silicon electronics is nearing completion, and nanotechnologies are being replaced by quantum technologies that operate on ions, atoms and elementary particles. This means that the rules for building computers will change: information theory will need to be adapted: the laws that describe the rules of behavior in the quantum world will have to be taken into account. One of the most probable scenarios of information theory development is investigated. The paper focuses on understanding "elementary" objects, operations, and simple systems of quantum information theory to study their properties. That is, for a promising generation it is necessary to develop conceptual models of work for conditions where the classical rules of physics and computer science will not be fulfilled by virtue of other laws of physics that affect monoatomic processors. In particular, one of the conditions affecting a monoatomic carrier is the condition of "Schrödinger cat" – the storage cell is simultaneously in the states of zero and one. This condition requires the development of specific protocols for data processing and transmission and reproduction; that is, a significant correction in the laws of information theory is required. To do this, the author reviews the problem and formulates the problem to be solved. Any material object or process is the primary source of information. All its possible states constitute the source code of information.

## Keywords

risks, quantum information, supersymmetry, muon

## 1. Introduction

The discovery of the last decade has made it possible to implement fully automated adaptive cybernetic systems for their direct interaction with humans. Computer vision works as an element of perception of the external environment. People began to understand the basics of the processes taking place in the brain and already implemented implants (artificial arms, legs, eyes, toys, etc.). The U.S. Department of State's automated identification system processes more than seven hundred and five million photos a year. We live in the era of the next round of cybernetic technologies - the era of the Industrial Revolution 4.0 [1]. The dynamics of the emergence of new concepts, methods and relevant opportunities (theoretical, applied developments) [2] is rapidly moving to the moment where society reaches a point where the laws that have served as a support for science can no longer describe the rules of cybernetic systems, and the ability to

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reliably predict the flow of information in 15-20 years is impossible to predict today. This will happen because the principles of information dissemination can be based on fundamentally new models [3, 4], which we do not use today. Moreover, although such an assumption for people, who want to fall into the field of adaptive IT research, seems a bit premature, but the worst-case scenario is that this is the only possible model of development. In this paper, the authors explores one of the most likely scenarios for the development of information theory.

Today there is a clear structure of definitions of concepts used in information technology, i.e. information, messages, signal, data, entropy – these are different concepts that have a clearly defined place in information theory. In the theory of information, information is considered as a quantitative measure to eliminate uncertainty, which decreases as a result of obtaining some information.

Let us introduce several definitions:

**Information** is new knowledge that the consumer receives as a result of the perception of certain messages.

**Knowledge** is a set of data (from an individual, society or artificial intelligence system) about the world, including data on the properties of objects, patterns of processes and phenomena, as well as the rules of using this information for decision-making. In other words, knowledge is a reflection of reality (objects, situations) in the form of concepts, relationships (subjective image of objective reality).

**Subject knowledge** is the ability to solve problems independently in the subject area, i.e. to use the available data to achieve the goal.

**Data** is a message recorded on a specific medium and presented in a form convenient for receiving, transmitting, processing information-analytic system (human or device).

A **message** is a sequence of signs, signals or physical processes that change over time, i.e. those that have a material and energy basis.

The theory of information is based on the method proposed by K. Shannon for calculating the amount of information that contains one random variable relative to another random variable. The amount of information in a message is determined by how much uncertainty is reduced after receiving the message. From this point of view, the amount of information contained in the received message is the greater, the greater the uncertainty before the transmission of the message.

If the state of an object or system is known in advance, then the message about this state does not carry any information for its recipient. If we receive new information about the state/condition of the observed object, then this message carries new information that will increase knowledge about the object. In this case, it is said that such a message contains some information for its recipient.

Thus, in the first approximation, information can be defined as new, previously unknown knowledge about the state of an object or system, and the amount of information is the amount of this knowledge. It is clear that if new knowledge increases the general level of knowledge about the state of the observed object, the amount of information accumulates and has an additive nature.

As a result, before the source sends a message to its recipient, there is uncertainty about the content of the message about the state of the object of observation. After selecting a message, the source generates a certain amount of information, which reduces this uncertainty.

The theory of information is based on the method proposed by Claude Shannon to measure the amount of information contained in one random variable relative to another random variable

[5, 35]. This method allows you to express the amount of information in numbers and provides an opportunity to objectively assess the information contained in the report.

Consider the basic calculations of Shannon's probabilistic approach to determining the amount of information.

Let a discrete source of information output a sequence of messages $x_i$, each of which is selected from the alphabet $X=\{x_1, x_2, \dots x_i \dots, x_k\}$, where $k$ is the capacity of the source alphabet. Each elementary message for its recipient contains information as a set of information about the state of an object or system.

In order to abstract from the specific content of information, i.e. its semantic meaning, and to obtain the most general definition of the amount of information, the quantitative measure of information is determined without taking into account its semantic content, as well as value and usefulness for the recipient.

Before the connection takes place, there is uncertainty as to which of the possible messages will be transmitted. The degree of uncertainty in the transmission of the message $x_i$ can be determined by its a priori probability $p_i$. Therefore, the amount of information containing one average message $I(X_i)$ will be some function of $p_i$: $I(X_i)=f(p_i)$. You mean the type of this function.

Let the measure of the amount of information $I(X_i)$ correspond to two properties:

1) if the choice of the source message $x_i$ is known in advance (there is no uncertainty), ie we have a reliable case, the probability of which is $p_i=1$, then $I(X_i)=f(1)=0$;

2) if the source sequentially issues messages $x_i$ and $x_j$, and the probability of such a choice $p_{ij}$ is a compatible probability of events $x_i$ and $x_j$, then the amount of information in these elementary messages is equal to the sum of the amount of information in each of them.

The probability of the joint loss of two random events $x_i$ and $x_j$ is equal to the product of the probability of one of these events and the probability of the other, provided that the first event occurred, another words $p_{ij}=p_i \cdot p_{j/i}=P \cdot Q$.

Then, from property 2 of the amount of information, it follows that

$$I(Xi, Xj)=I(Xi)+I(Xj)=f(P \cdot Q)=f(P)+f(Q).$$

It follows that the function $f(p_i)$ is logarithmic. Therefore, the amount of information is related to the a priori probability ratio

$$I(X_i) = k \cdot log\, p_i,$$

here $\boldsymbol{k}$ – the capacity of the probable message alphabet;

$\boldsymbol{p_i}$ – the probability of the $i$-th message

$\boldsymbol{X_i}$ – random value of the $x_i$ -th message;

$\boldsymbol{\kappa}$ and the base of the logarithm can be arbitrary.

That the amount of information was determined by a non-negative number, taken $k=-1$, and the basis of the logarithm for ease of calculation on a computer choose 2, then we have:

$$I(X_i) = -\,log\, p_i.$$

That is $\log p_i = 2^{I(X_i)}$ and in general evidence for computer:

$$I(X_i) = \sum_{i=1}^{k} p_i \log_2 p_i \tag{1}$$

In this case, a unit of information is also taken bit. Thus, a bit is the amount of information in a message of a discrete source, the alphabet of which consists of two alternative events that are a priori equally likely. If the number of a priori equally probable events is 28, then the byte is taken as a unit of information.

If the source of information gives a sequence of interdependent messages, then receiving each of them changes the probability of occurrence of the following and, accordingly, the amount of information in them. In this case, the amount of information is expressed through the conditional probability of choosing the source of the message $x_i$, provided that the messages $x_{i-1}, x_{i-2}$ …, i.e.

$$I(X_i/X_{i-1}, X_{i-2}, \dots) = -\log_2 p(x_i/x_{i-1}, x_{i-2}, \dots) \qquad (2)$$

The amount of information *I(X)* is a random variable because the messages themselves are random. The law of probability distribution *I(X)* is determined by the probability distribution *P(X)* of the ensemble of source messages.

## 2. The concept of source entropy

The entropy of the source (specific amount of information) is the amount of information contained in one elementary message $x_i$. The entropy of the source is determined by the formula introduced by Claude Shannon in 1948 [5, 35]:

$$H(X) = -\sum_{i=1}^{k} p_i \log_2 p_i = \sum_{i=0}^{N-1} p_i \log_2 \left(\frac{1}{p_i}\right), \qquad (3)$$

here $H(X)$ – the entropy of the source;

$p_i$– the frequency with which the $i$-th letter occurs in the language in which the message is written.

$\boldsymbol{k}$ – the number of letters in the source alphabet.

Here $\log_2 \frac{1}{p_i}$ is interpreted as a certain amount of information $I_i$, obtained during the implementation of the $i$-th option. Entropy in Shannon's formula is the average value of a set of a sequence of numbers with different information capacity, i.e. it is a mathematical expectation of the distribution of a quantity $I_0, I_1, \dots, I_{N-1}$.

The physical content of entropy is an average measure of the uncertainty of the knowledge of the recipient of information about the state of the observed object.

### 2.1. Formulation of the problem

Moore's Law is an empirical law according to which the number of transistors in a crystal of one integrated circuit doubled every year for the first 15 years, and then, and to this day, such doubling occurs every 1.5 years. Therefore, if the first silicon chips were implemented on the technology of tens of microns, today the working control is carried out at 10 nm (Intel), 7 nm Qualcomm Snapdragon 865+ (AMD) and 5 nm (Apple A14). IBM has demonstrated a "quantum mirage" effect, in which an atom can store one bit of information [19]. In addition, one atom is the limit beyond which quantum effects can be a real issue with reliability, as the behavior of such small objects begins to be described by the rules of quantum physics, such as electronic tunneling. Therefore, nanoconductors can no longer conduct electrons according to the laws of classical theory - in the usual way: in the form of a stream of charged particles in a solid. Recall that quantum mirages were discovered by Hari Manoharan, Christopher Lutz.

If Moore's Law continues to operate, in less than 20 years the size of the integrated circuit will be at the level of atoms. That is, the laws of their operation will be determined by quantum mechanics. Today, there are many inconsistencies in describing the behavior of nanoworld objects in classical systems. For example, the very fact of observing an atom disturbs its motion, and the absence of observation leads to a blurring of its velocity and trajectory (lack of trajectory – the ratio of Heisenberg uncertainty) – as if it is in several places at once (at one point in time). Thus, quantum effects are perceived as an obstacle in the design of ultra-small computers. Quantum computer science must figure out how to use fundamental quantum properties.

Fundamental interactions appeared due to spontaneous symmetry breaking in the first moments of the universe's existence. Modern cosmological theories consider the evolution of the universe, starting with the so-called Planck moment, 5.4 × 10-44s. After that, the only field that had the greatest symmetry disintegrated, and gravity separated from it. To avoid a long description, we reflect the current state in Fig. 1:

So, the formulation of the problem:

***Problem 1*** - reducing the size of computational elements and integrated circuits has a natural limit - the point when the laws of quantum information theory will replace the laws of classical information theory, respectively, there is a need to explore the extension of information theory to quantum information theory.

***Problem 2*** - reducing the share of energy dissipated. Logically inverse operations are operations that are not accompanied by energy dissipation (Landauer, 1961). Thus, to perform classical calculations requires a physical system that has two stable states, such as triggers in electronics, which provide information in the form of a binary system.

## 3. Research of quantum properties of information carriers

The idea of using quantum properties of information carriers to accelerate the process of computation and development of the quantum computer is attributed to the American physicist R.-F. Feynman [7, 8], and improvement to the English physicist D. Deutsch [9]. E. Bernstein and W.W. Vazirani in 1993 proved the possibility of performing an arbitrary unary operation in quantum calculations using a finite number of operations (universality of the quantum Turing machine) [10]. American scientists P. Shore and L. Grover have developed algorithms that fully use quantum interference and entanglement for significant (compared to classical) computational acceleration [11, 12]. Methods of controlling nanoscopic particles by creating and controlling coherent quantum states, which led to the creation of experimental implementations of qubits (quantum information carrier), are presented. Additional studies of quantum computing can be found in [13].

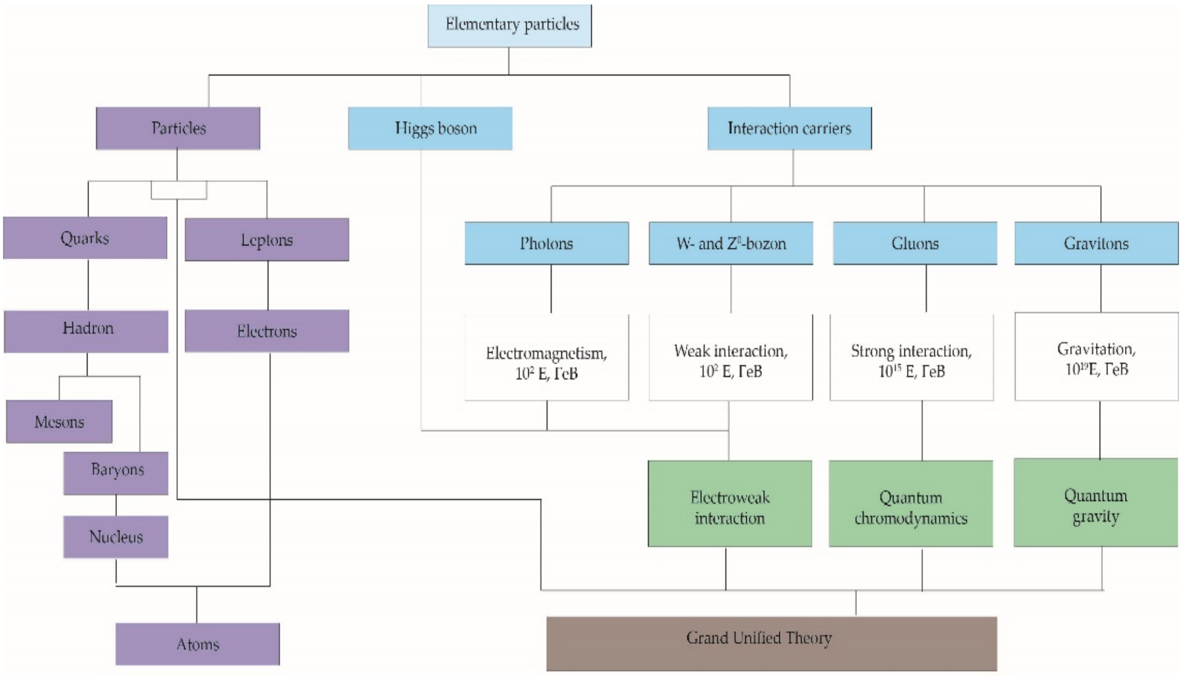

**Figure1:** Basic forces of interaction and elementary particles

In practice, it can be said that commercial devices for creating quantum communication lines (QPN Security Gateway by MagiQ Technologies (USA), cryptosystems Clavis and Cerberis by ID Quantique (Switzerland)) have long been on the market. In the last decade, leading laboratories have been fighting for quantum dominance at the level of commercialization of quantum computers [34]. Thus, today, we see that the IT industry is preparing for the transition to a new ideology of servicing information flows. Accordingly, Ukrainian participants must prepare for the rules of the game of the future.

Therefore, consider the known elements of quantum information transfer. By analogy with the classical theory of information, we systematize the concept of quantum information theory.

***Definition.*** Quantum information – information contained in the state of a quantum system. It is the subject of the study of quantum information theory.

***Definition.*** A quantum object is an object of the nanoworld (electrons, atoms, molecules, light clusters) to which the rules of quantum theory apply, in particular, its description in terms of states that are statistical in relation to all measurement results;

The information carrier is the state of the quantum system $H$, which is an information resource because it is statistically uncertain

The state of a quantum object is a list (catalog) of possible measurement results performed on it. In quantum mechanics, two states of objects are considered: pure and mixed.

Pure states describe objects that are independent of all other quantum objects around them. Mathematically, the pure state is given by the state vector (wave function), which is usually written in Dirac notation as a cat vector $|\Psi\rangle$. This vector belongs to the multidimensional complex Euclidean space, which is called the Hilbert space of the physical system. The dimension of the Hilbert space $D$ specifies an important parameter - the number of independent states (levels) of the quantum system. Using as orthogonal vectors mutually orthogonal vectors

$|i\rangle$, forming a complete set $\sum_{i=1}^{D}|i\rangle\langle i| = \hat{I}$, we can represent an arbitrary state vector in the form of a linear superposition of basis vectors :

$$|\Psi\rangle = \sum_{i=1}^{D}|i\rangle\langle i| = \hat{I} \tag{4}$$

The choice of basis is determined by the procedure of the physical experiment and its integral part - measurement. There are an infinite number of orthogonal bases, and hence an infinite number of different representations of an arbitrary state vector.

The simplest example Mixed states are described using a density matrix:

$$|\Psi\rangle = \sum_{i=1}^{D}|i\rangle\langle i| = \hat{I} \tag{5}$$

The simplest example of a superposition might be a state vector of a system having two orthogonal states and $|\Psi_1\rangle$ and $|\Psi_2\rangle$ [16]. The state of such an object is described by a state vector (wave function):

$$|\Psi\rangle = \alpha|\Psi_1\rangle + \beta|\Psi_2\rangle\,, \tag{6}$$

here $\alpha$ *and* $\beta$ – complex numbers or amplitudes of states, when

$$|\alpha|^2 + |\beta|^2 = 1. \tag{7}$$

During the measurement, the coherent superposition (6) is destroyed and reduced to a new state, which is determined by the type of measurement. Yes, when trying to find a system in the state $|\Psi_2\rangle$ perturbation of the measuring instrument will lead to the fact that at the time of measurement there will be a reduction (design):

$$|\Psi\ \rangle \Rightarrow\ |\Psi_2\rangle\langle\Psi_2|\Psi\rangle \Rightarrow |\Psi_2\rangle, \tag{8}$$

as a result of which the system after measurement will pass to the state $|\Psi_2\rangle$, and the initial state will cease to exist.

$$p_{mix} = |\alpha|^2|\Psi_1\rangle\langle\Psi_1| + |\beta|^2|\Psi_2\rangle\langle\Psi_2| \tag{9}$$

This state is essentially classical, because in the mixed state (9) the system can be either in the state $|\Psi_1\rangle$, or in the state $|\Psi_2\rangle$, whereas in the superposition state (6) the system can be in two states simultaneously.

In the work of Erwin Schrödinger "The current state of quantum mechanics" [14] analyzed the features of quantum mechanical processes and formulated four main provisions that characterize the state of a quantum object:

The principle of superposition. The state of a quantum object is described by a linear combination of basis states;

The principle of interference. The measurement result depends on the relative phases of the wave functions included in the superposition state;

Entanglement of quantum states. Complete information about the state of the whole system does not correspond to the same complete information about the state of its components;

Non-cloning and uncertainty. The unknown quantum state cannot be copied or observed without its perturbation – the state is described only statistically [15].

Quantum entanglement states are a quantum mechanical phenomenon in which the quantum states of two or more objects are interdependent. This interconnection persists even if the entangled particles are spatially spaced beyond any known interactions. Measuring the parameter of one particle causes instantaneous (more than the speed of light) destruction of the confused state and determining the state of the second particle with one hundred percent probability. Such behavior does not agree with the principle of locality, but does not violate the theory of relativity, because there is no transfer of information.

A good example of confused states are photon pairs in Bell states [17].

## 3.1. Quantum calculations

The changes that occur with the quantum state can be described in the language of quantum calculations. The fundamental model of quantum computing is quantum schemes. By analogy with the classical computer, which contains wires and logic elements, a quantum computer is built of quantum circuits consisting of wires and elementary quantum elements that allow the transmission of quantum information and manipulate it.

The evolution of an unmeasured quantum system translates the initial state of the quantum system into another state while maintaining the norm. For Hilbert space, the transformation must be reversible, i.e. unitary. Any transformation on a *d*-dimensional complex vector space can be described using a matrix of size $d \times d$. Let $M^*$ be a transposed complex-conjugate matrix with respect to the matrix *M*. A matrix M is called unitary (one that describes unitary transformations) if the condition $M^*M=1$ is satisfied. An arbitrary unitary transformation of quantum space is an admissible quantum transformation, and vice versa. Thus, the condition of unitarily is the only restriction imposed on quantum elements. Unitary transformation can be interpreted as rotations in a complex vector space.

A quantum computer is a device that performs logical operations on quantum states by unary transformations (that is, energy-saving ones) without disturbing quantum superposition in the computational process. Schematically, the operation of a quantum computer can be represented as a sequence of three operations:

1) "record" - reading the initial state;
2) "calculations" - unitary transformations of initial states;
3) "output" of the result (measurement, design of the final state).

## 3.2. Qubit

By analogy with a classical computer operating on a sequence of classical bits, a quantum computer operates on a sequence of quantum bits. Thus, the fundamental unit of information in quantum information systems is a quantum bit (quantum bit) or abbreviated qubit (qubit). Some quantum system with two stable states can be used to represent the qubit. Many different physical systems are used to implement qubits. For example, in a model of an atom, an electron can exist either in the ground $|0\rangle$ or in the excited $|1\rangle$ states. By irradiating the atom with light with a certain energy, it is possible to make transitions between these states.

A significant difference between a qubit and a classical bit is that a qubit can be in an indeterminate (non-statistical) state other than 0 or 1. Let us call this state non-statistical in contrast to $|0\rangle$ and $|1\rangle$, which are statistical states.

A linear combination of states is a superposition:

$$|\Psi\rangle = \alpha|0\rangle + \beta|1\rangle \tag{10}$$

We now show the rule of change in the classical addition (table 1) and the use of "quantum entanglement" (entanglement of quantum states) (table 2).

**Table 1**
Classic bitwise addition

| a | b | a⊕b |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 1 | 0 |

**Table 2**
Addition taking into account the quantum effect

| a | b | a′ | b′ = (a⊕b) |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 |

In table 2, the value of qubit a is stored, the value of qubit b changes according to the law XOR. Bit b - (target) changes its state only when the state of the control bit = 1; the state of the control bit does not change. Thus, we see why, in the general case, logical data can be cloned and quantum data cannot. In the general case, quantum data means the superposition of the form:

$$|\Psi\rangle = \alpha|\Psi\rangle + \beta|\Psi\rangle$$

here $\alpha$ i $\beta$ – complex numbers or amplitudes of states, when $|\alpha|^2$ i $|\beta|^2 = 1$.

### 3.3. Quantum entropy (von Neumann entropy)

Suppose that for a quantum mechanical system of density $\hat{p}$ we have $|p_i\rangle$ - eigenvectors of the density matrix corresponding to the eigenvalues p_i (for simplicity, we take them as nondegenerate matrices), then

$$\hat{p}_i|p_i\rangle = p_i|p_i\rangle,$$

here $p_i$ – the probability of finding a quantum system in the pure state $\hat{p}_i = \ |p_i\ \langle p_i|$ . Here $0 \leq p_i \leq 1$.

In the basis, $\{|p_i\}$ the density matrix takes a diagonal form. Therefore, in the basis of eigenvectors, quantum entropy (or von Neumann entropy) can be determined similarly to the classical (information entropy H(X) Shannon using eigenvalues:

$$S = -\sum_i \ p_i \ln p_i,$$

here s – it is a theoretical and informational entropy.

In quantum information theory, quantum relative entropy is a measure of the difference between two quantum states (a quantum-mechanical analogue of relative entropy] [21].

In contrast to classical information theory, quantum theory contains the concept of entropy of entanglement.

Entropy entanglement is a measure of the degree of quantum entanglement of two subsystems that form two parts of the composite of a quantum system. Thus, the entropy of entanglement is the von Neumann entropy of the density matrix for an arbitrary subsystem. If it is not equal to 0, then the system is in a mixed state, which means that the two systems are entangled.

### 3.4. Research results and their discussion

Quantum information theory. The main tasks of Ph.D. is the establishment of conceptual capabilities and limitations of receiving, transmitting and processing information in quantum media (systems that operate according to the laws of quantum mechanics). It is believed that the theory of classical information works with shortcomings in its use in the real world (quantum world). Schematically, this can be represented as

### 3.5. Quantum information ⊂ Classical information ⊂ Information technology

The concept of communication channel and its maximum bandwidth is an important element in quantum information theory, because the effect of quantum entanglement allows not to send information physically, through quantum teleportation.

Obviously, the application of quantum information theory is necessary when information is received, stored, transmitted not by bits, but in terms of quantum states.

Determining the degree of confusion for systems with more than two components, as well as for noisy systems in the so-called mixed states, is a separate problem of quantum information theory. Fundamental developments in this direction belong to the school of Polish physicists Gorodetsky [18]. It is believed that the definition is a principle. restrictions on the confusion that can be released for information processing will make it possible to formulate the postulates of quantum information theory by analogy with the postulates of thermodynamics. Currently, the main problem of quantum information theory is to overcome the so-called quantum gap – the transition from already implemented computers with 5-10 qubits to a machine that can create superpositions and confused states of 1000 qubits and perform (until the state decays) at least 109 operations [19].

## 4. Experiments and Results in quantum theory area

### 4.1. Symmetry

The modern theory of everything (superstring theory), which claims to be the unifying theory of all four fundamental interactions, is based on a model of supersymmetry. Supersymmetry is a theory that connects bosons and fermions in nature (we can say that the transformation of supersymmetry can translate matter into interaction (or radiation), and vice versa). Supersymmetry provides a union with gravity (local supersymmetry is the theory of gravity); leads to the union of strong, weak and electromagnetic interactions (the theory of the Great Union); solves the problem of hierarchies (simultaneous existence of large and small scales); creates insufficient dark matter in the universe. Supersymmetry provides superstring theory with consistency and stability. Supersymmetry "relieves us of the need to fine-tune the parameters of the standard model to overcome a number of subtle problems in quantum theory ... at insignificantly short distances, supersymmetry changes the intensity of three non-gravitational interactions so that they can merge into one large combined interaction" [27].

Parts of the construction of string theory gradually fell into place" [28]. The new symmetry in physics is called supersymmetry. She argues that in the permutation of bosonic and fermionic particles, the physical laws must remain unchanged. It is like a mirror image of nature, in which fermions turn into bosons and bosons into fermions. The search for various manifestations of supersymmetry in nature is one of the main tasks of numerous experiments on modern particle accelerators. Symmetry is the basis of all the fundamental laws of physics: the law of conservation of momentum as a consequence of the homogeneity of space; the law of conservation of momentum as a consequence of isotropy of space; the law of conservation of energy as a consequence of the homogeneity of time; the law of conservation of velocity of the center of mass (consequence of isotropy of space-time). This has been actively explored in the works [29]. Systems were built using simulation based on a quantum computer in [30]. Image protection was implemented in [31]. Software and hardware were implemented in [32] for the mobile system. Neural networks have been used to encrypt and decrypt data in [33].

## 4.2. Study 2021

The standard model is a currently accepted theoretical construction that describes the interaction of all elementary particles in the universe. It assumes four fundamental interactions: electromagnetic, strong, weak, and gravitational.

However, this is by no means a definitive theory. This is evidenced, for example, by the presence in the universe of dark matter or antimatter, which does not fit into the Standard Model. And now scientists are approaching the so-called New Physics.

The standard model accurately predicted the so-called muon g-factor, an indicator of the strength and speed of rotation of a particle in a magnetic field. This factor is close to the value of 2, but the Brookhaven experiments revealed a deviation of several parts per million.

Despite the minimal difference, the scientists claimed the existence of previously unknown to science interactions between the muon and the magnetic field.

The Muon g-2 [34] experiment at the Fermi National Accelerator Laboratory (Fermilab) in Chicago on April 7, 2021 published the results of an experiment that was to measure the value of the anomalous magnetic moment of a muon with high accuracy.

The current state of research [35] shows a possible change in both unifying theory and the theory of everything. Forces of interaction model can be tested in the near future with accelerator-based experiments and possibly also at the precision frontier.

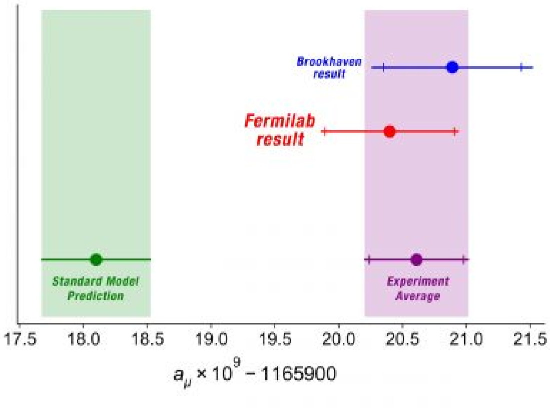

**Figure 2:** Correlation of oscillation frequency with the standard model (Fermilab)

The first result from the Muon g-2 experiment at Fermilab confirms the result from the experiment performed at Brookhaven National Lab two decades ago. Together, the two results show strong evidence that muons diverge from the Standard Model prediction. Image [36].

Thus, in the course of research as part of the Muon g-2 experiment in the laboratory of the town of Batavia near Chicago (with a probability of 1 chance out of 40,000, i.e. the statistical level of reliability is 4.1 sigma), a new, fifth force of nature was discovered [37-40]. Probably because, the permissible error leaves to recognize the discovery by science, the error should not exceed one chance by 3.5 million (5 sigma).

## 5. Conclusions

Obviously, the era of silicon electronics is nearing completion, and biotechnologies that operate on DNA molecules and quantum technologies that operate on ions, atoms, and elementary particles are replacing on-technology.

Quantum computing and quantum information are new tools that will create a link between simple and relatively complex: in the field of calculations and algorithms there are systematic tools for building and studying such systems. The application of ideas from these areas has already led to the emergence of new views on physics, so the authors contributing to the expansion of general information theory by supplementing by integrating into its foundation the rules of computation in quantum systems. The author systematizes the concept of different industries and introduces the concept of non-statistical state.

To understand further development, it is necessary to formalize the current state of affairs. Procedures for determining all the rules of interaction and construction of the corresponding algebra today are called theories of everything.

***Definition.*** Fundamental forces - different types of interaction that are not reduced to each other. The fundamental forces described are gravitational, electromagnetic, strong and weak interactions. It is considered (the theory of everything) that all these 4 interactions are separate cases of one, still unknown, hypothetical interaction. The case of describing the theory of everything is constantly supplemented by new manifestations, which cannot be substantiated by the above-mentioned four fundamental forces. In particular, such quantum effects as quantum entanglement and uncertainty without observation and acceptance of value in the process of observation cannot be justified by the influence of one of the four forces.

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