Some information and logical properties of multistable semiconductor plazma are discussed and the concept of physical logic system $L_p$ on their basis is entered. $L_p$ contains exclusively values of some quantitative characteristic physical size of plazma and transformation of a set of such sizes by means of plazma-field interaction.

The opportunity nonmathematical (physical) calculation in $L_p$ is considered and as an example by symbols $L_p$ are submitted classical arithmetic-logic actions, i.e. their physical models in system $L_p$ are found.

1. **Physics in information science**

Quantum physics played rather funny role in informational - computing technologies. It raised on a qualitatively new level the sphere of implementation of mathematical calculus on the basis of the Boolean logicians. Achievements in the field of technologies, algorithms and the architectures have provided and continue to provide huge successes. But the quantum physics itself by its laws braked the powerful triumph of a classic electronics engineering, limiting a capability of mathematical computers and giving rise principled crisis in information technologies.

The germs of this crisis were pledged also in the fundaments of the physical theories and have preceded the semiconducting electronics engineering, born by the quantum mechanics. Thus the basis served not only the boundedness fundamental constant $0 < h_1, k, c < \infty$, but also information and logical bases of the physical theories [1-7]

Germs of crisis of became more subjected by the appearance of integral technology and microelectronics, also born by the quantum physics [8,9]

The completion of this process became the appearance of nonostructure on the stage. It became evident that if to keep the operational principles of mathematical calculus on the basis of the Boolean logician, some broad classes of problems will be unsolved also in this case [6, 7, 10-13]

As convincingly enough has pointed R. Feynman [6] this crisis, arisen because of physical limitations, necessarily must be overcome by the physics.
From a finiteness of universal constants the sequence of the following simple facts follows:
for implementation of the operation (conversion, carry, processing, storage etc.) above one bit of the information of a physical system (PS) the finite time, volume of space, power consumptions and negentropies are necessary, which are the characteristics of PS. Any classic association (i.e. with the classiced correlate parallelism) \( m \) such PS for \( n \) acts can process the information no more, than \( n^{k(m)} \) of bits, thus the characteristic of collective \( k(m) < \infty \).
It means, that under such prescription only polynomial restricted algorithms are feasible.

Besides on the basis of the classic (determined) machine it is possible to model classic probabilities, and the quantum probabilities can only be imitated, as legibly enough argued R. Feynman [6,7] Even for their imitation it is necessary to know beforehand about properties of quantum probabilities, and for modeling it is necessary, that the machine itself had properties of quantum probabilities, i.e. logic nonclassical, accepting a superposition of condition and its interference.

In connection with it, it is possible to distinguish two main reasons, responsible for the currently arisen crisis in informational computing technologies; at first, the information efficiency of the elementary act of calculus is minimum, in second the classic logical basis of calculus itself is minimum.

Both reasons are partially interdependent, therefore clearly or not clearly, they must appear simultaneously. It is visually visible on a model example \( q \)-bit, which is represented in PS with two absorbing states \( |0\rangle, |1\rangle \) and their coherent superposition (indeterminated condition):

\[
|\alpha\rangle = \alpha_0|0\rangle + \alpha_1|1\rangle; \quad \alpha_0^*\alpha_0 + \alpha_1^*\alpha_1 = 1.
\] (1)

Because of existing correlation between \( \alpha \). Here \( \alpha \) condition is arbitrary therefore possesses a huge quantity of information, and its indeterminated nature is a lien for applying \( q \)-bit PS in modeling of quantum probabilities.

If to consider the conditions \( |0\rangle, |1\rangle \) and \( |\alpha\rangle \) accordingly as expressions ”lie”, ”truth”, ”indefinitely”, we shall receive three-digit quantum logician [2,14] besides informal in the sense that \( |\alpha\rangle \) really is true indefinite, and not just by our definition.

It is necessary to mark, that thanks to \( \alpha \) we manage to receive quantum - PS from \( n \) \( q \)-bits, which is capable to convert problems with exponential algorithms to polynomial problems. More composite algorithms can be converted to polynomial, if instead of (1) the following PS is used:

\[
\alpha = \sum_{i=1}^{k} \alpha_i|i\rangle; \quad \sum_{i=1}^{k} \alpha_i^*\alpha_i = 1.
\] (2)

Unlike (1), in (2) figure \( (k-1) \) indefinite elements, therefore the last describes more consistent logical system. This example demonstrates, that the difficulties in information technologies have arisen not because of the physical laws and PS, but because they are not sufficiently used. The informational and logical properties of the nature are much wider, than the currently used the one-bit information science and Boolean logician.

In order to use PS in computing process more effectively, we shall return to the analysis of the essence of activity of the mathematical computing (MCM).
The input information - datas and algorithms, is represented on the basis of algebraic pattern. However, MCM executes only logic operations of logical system (Boolean algebra of logicians), therefore it is necessary at first to pass in algebra the logicians (if necessary can be intermediate transition in a system with binary coding). Later, all the present logic operations in algorithm are executed, then all reconversions are made in converse order. The logical reasoning or not obviously are present in any link of calculus processing (for example, for compiling algorithm, or some rule, or, program of calculus). But all of them are executed outside of the machine, in which only the logical operations and information transfer are executed. And the mideast role of physics consists here in implementation of these latests under the simple scheme; to presence of the information carrier (signal) is confronted the true expression, to the absence - false, and the logical operations (functions) became conversion of input signals in output in accordance with functional settings of these operations. The nature of mathematical calculus is those. But this is not the only way to realize calculus. It is possible to make calculus of other nature, physical, without logical or further without arithmetic operations, and to receive the same result but in the other conception. Two circumstances support this proposal [2,5,14,17]

1. Information quantitative measure of order (on some parameter) PS - is a physical quantity which is capable:
   - to be latent in system,
   - is entered in a system and is injected from a system,
   - is transferred in space and time both inside the system and outside of it,
   - to be converted in a system,
   - to interact in a system with other informations and physical quantities.

2. In PS (and processes in them) definite logical resources are hidden (logical expressions, formulas, operations etc.) correspondent to the physical laws and legitimacies operating in the system. The information demonstrates a fraction of negentropy which has been turned into the order on the given set of PS microcondition, and the expression presents a measure of rejection from chaos at the given microcondition, or, that is equivalent to a measure of veracity (verity) of transformation of the negentropy in the internal order PS in the given microcondition. On the other hand, the information presents a ranked measure of PS and is the quantitative physical characteristic of set of all microcondition, the logical expression quantitatively describes concrete (discrete) condition, introducing a measure and regularity of transformation of negentropy into the information at the presence of the given condition.

Thus, there are at least partial conformity between a physical quantity $\xi_p$, describing the given microcondition, by the expression $\xi_\ell$, introduced microcondition, and abstract number $\xi_h$, and correspondently by the physical operations above set $\{\xi_p\}$, logic operations above set $\xi_\ell$ and algebraic operations on $\{\xi_h\}$.

Just the conformity of algebras of quantitative abstract numbers and the logicians have resulted to MCM. In mechanical machines (for example ”Feliks”, system of interdependent
neuron) the arithmetic operations are made through algebra of logicians located in our mind, i.e. "Feliks" is not the independent machine. The program of calculus is also stored outside of the machine.

In classic computers the Boolean algebra of logicians is realized, therefore transition to binary algebra is previously committed. Here outside of the machine is the main part of logician, the remaining is inside it.

In both cases the conformity with physics is not used, in view of which it is possible to make calculus, even partially using latent logician of PS.

Moreover, it is possible to take such set of PS, that latent logician has ensured the existence of the logical system, which was self-contained and full for the given purpose (let’s say, for the implementation of arithmetic operations). The physical quantities (quantum quantity of microcondition) and physical operators should figure, basically, in this logical system, therefore we shall call physical and we shall designate through $L_p$. $L_p$ not necessarily should be algebra of the logicians, but can contain such (for example, Boolean algebra logicians). By eligible selection PS it is possible to construct algebraic pattern above $L_p$ and to write algorithms of calculus and the applicable machine will be physical.

For more visual demonstrating of these ideas and their reality, below is presented one such example: the simplest physical logical system multivalued and determined.

2. Calculus on the basis of multistable plazma

The intuitive extension of the logical fundamentals of calculus is connected with transition in the multivalued logician. In order the internal logician is multivalued, it is necessary the PS to be multistable.

In the nature there are a lot of PS with multirepeatability on any parameter: optical, electrical, $q$-bits, neurons, quantum (Josephson effect, quantum Hall effect and i.e.), each of which can spawn some different logical systems. From behind such outrage more effectively at first it is purposeful to select satisfactory logical pattern $L_p$, which will dictate itself PS or functional properties.

Let us have different $\xi_i$ of values of convertible value ordered in ascending order and

$$ h_p = \{0, 1, \ldots, E\}; \quad E = p - 1. $$

The abstract number $i \in h_p$ indicates both the value of a physical property (quantum number) describing $i$ condition, and correspondent logical expression, and also input information condition.

The set $\langle \xi_{i1}, \xi_{i2}, \ldots, \xi_{ik}\rangle$, we call $k$-local $P$-ical condition (physical, logical, information and algebraic), and bracket $\langle \cdot \rangle$, conjunctive, if there is a period $\Delta t \geq \tau_{\text{char}}$ such, that $\forall I \in h_p$ all $\xi_{ni}$ simultaneous (and separately in a case of logician determined considered here) act. Let’s designate through $H_k(p)$ set of every possible such condition.

Here $\tau_{\text{char}}$ characteristic time of transition PS from one condition into another. We enter also the concept of alternatively disjunctive bracket $\left[ x_i \atop x_j \atop x_m \right]$, that $j$ line has place in
fulfillment of \( j \) condition, which is incompatible with any \( I \) condition at \( I \neq j \).

Set \( \langle [], \ldots, [] \rangle \) \( m \) - local such brackets we shall designate through \( S h_m \).

As normal subset \( H^0_k \) sets \( H_k \) we shall call combination of every possible condition \( \langle x_1, \ldots, x_k \rangle \in H_k \) such, for which the condition is satisfied:

\[
\sum_{i=1}^{k} x_i \leq E. \tag{3}
\]

The definition (3) of sets of condition \( H_k \) decompose to two classes; the class of normal condition \( H^0_k \) and its addition to \( H_k \).

Let’s define also (logical) norm of condition from \( H_k \).

\[
|\langle x_1, \ldots, x_k \rangle| = \min (\Sigma x_i, E) = \begin{cases} 
\Sigma x_i, & \text{if } \langle x_1, \ldots, x_k \rangle \in H^0_k \\
E, & \text{if } \langle x_1, \ldots, x_k \rangle \notin H^0_k.
\end{cases} \tag{4}
\]

The second equaling in (4) follows from definition (3).

The norm of a condition introduces a general measure of the verity of the expressions inclusive in this condition, in which the information \( k \log_2 P \) is also accumulated.

For the basis for construction of the physical determined logical system \( L_p \) we shall set elementary physical transformations of condition \( H_k \) (i.e. we shall define the physical operators above \( H_k \)).

A). The operation of inverse \( I_p \equiv j \) one-one is convertible compares to each member \( H_1(h_p) \) conjugate (additional) a member from \( H_1(p) \);

\[
I x \equiv E - x; \quad \forall x \in h_p. \tag{5}
\]

B). Same operation on a subset \( \{0, 1\} \) (i.e. Boolean denying):

\[
I_2 x = 1 - x; \quad \forall x = h_2. \tag{5''}
\]

And as multi-seater three imagery

1. \( K\langle x_1, x_2, x_3 \rangle \to I |\langle x_1, x_2, x_3 \rangle| \) \( \tag{6} \)

2. \( h\langle x_1, x_2, x_3 \rangle = \begin{bmatrix} E \\ 0 \end{bmatrix} = \begin{cases} 
E, & \langle x_1, x_2, x_3 \rangle \in H^0_k \\
0, & \langle x_1, x_2, x_3 \rangle \notin H^0_k.
\end{cases} \tag{7}
\]

3. \( S\langle x_1, x_2, x_3 \rangle = \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{cases} 
E, & \langle x_1, x_2, x_3 \rangle \in H^0_k \\
0, & \langle x_1, x_2, x_3 \rangle \notin H^0_k.
\end{cases} \tag{7'}
\]

The correlation (5) - (7) can be viewed as definition of functional properties those elementary PS, (the word ”elementary” here means, that given PS is one whole, one member (as the transistor)), which are multistable: have multiinput control, and the transformations make by the appropriate logician. The right members of definition (5) - (7) have describing nature, for example, \( x \to I x \), and \( I x = E - x \) simple for presentation of properties of \( I \) operator on the arithmetic language. In the system \( L_p \) there is no necessity for the expression such as \( (E - x) \).
We enter two more "trivial" operators: zero 0 and identical 1, which introduce accordingly absence of communications and identical communications (i.e. the transformation of physical signal or, that is the same, the numbers, information and expression).

Let's make a system \( L_p \left( h_p, \leq, \{,\}, \left[\begin{array}{c} - \\ 0 \\ 1 \end{array}\right], 0, 1, I, I_2, S, h, K \right) \) and pay attention that the operators on (5) - (7) introduce (basic) PS (we shall call them polistors of the given type [16, 17], for which all the symbols in \( L_p \) are either the significance of their characteristic physical parameters, or their property of physical transformation. For example, \( I \) - polistor makes \( I \) transformations \( \forall x \in h_p \) in other member \( Ix \in h_p \), i.e. \( Ix \equiv I(x) \) it is also possible to esteem as a physical quantity, which is made not through a difference \( (E - x) \).

It is necessary apart to point out, that here sign " \( \leq \) " (or " = ", " < " etc.) introduces not an algebraic logical correlation between the members, but arranges the physical quantities and its operatings are already enclosed in \( h_p \), and the sign itself could be excluded from \( L_p \), if only we do not want, to construct the logician or algebra of logicians on \( L_p \).

In order to demonstrate thesence of information and logical transformations of PS more visually we shall consider a particular example, perhaps \( K \)-polistor on the basis of multistable semiconducting EHP [8, 16-19] As was already said, by these conditions were conditioned the latent information and logician polistor. Let the external information be received by the located in non-equilibrium stationary state polister by a conjunctive set of control signals.

The physical nature of the information (and logicians) means, that, apart from energy, definite quantity of a negentropy is received in a system (proportionally to the norm of the input condition) in the addition of there existing negentropy. Now in polistor joint actions of both negentropies place joint actions of both negentropies take place which are capable to induce in the system the new order, if there is such a capability. In EHP the ordering can be made in relation to the contributions of different sorts of electrons and vacant electron sites, say, by relation of the number of electrons passing through a barrier to number of electrons, passing above a barrier; relation of electrons and vacant electron sites were used in formation of different conditions. The ordering on such parameter in space is localized on a place of receipt of the information. At the same time for implementation of transformation of the information with definite logic (regularity), it is necessary, that the proceeding information is spread on all PS. Such information field can be created in EHP by effect of plasma-field interplay.

After installation of this field, if the norm of the input condition (the entered negentropy) surpasses some threshold (or a little from them), at the expense of an external power source and entropy in the polistor a new condition is organized and the transformation of the input condition is realized. It is a kind of physical interplay of the external and internal orders and logical expressions with participation of external sources. For \( K \) polistor in \( H_k \) some physical conditions, due to a permutation symmetry of a conjunctive bracket, are logically indiscernible (i.e. have the identical norm, therefore, describe the identical expressions) and make equivalence classes. If make of these classes the factor set \( H_k/L_p \), there will be \( P \) members in it, when in \( H_k \) exist \( P_k \) conditions. And the property of \( K \) polistor is to make logic operation (physical transformation of the norms of condition), is conditioned by that lawfulness (is enclosed in it), according to which \( H_k/L_p \) is imaged in \( Sh_mk \). k-imagery \( H_k \) in

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6
Shₘ, agrees (6), is not one, but those is the k-imagery Hₖ/Lₚ in Sh₁. The last becomes logically convertible, remaining physically irreversible. Analyzing all characters Lₚ, we come to a conclusion, that apart from customary values, the information and logician have physical nature. In PS, particularly in polistors, there are quantitative conformity between its physical, information and logical quantitative characteristics and physical operatings above them, and also Lₚ is algebraic pattern, (but not by algebra), physical quantities and operators.

How much last is valid for representation on its basis the external information, logical, mathematical and physical processes and phenomena?

This problem can be reformulated. If an abstract logician is presented (lets say, Boolean), on the basis of its algebra of logicians are representable mathematical models therefore physical models are presented. At the same time are used definite quantity of logical resources. The problem arises, it is possible to decide a return problem: to present mathematical and logical models through physical with restricted quantity?

The example Lₚ is one, but not the only positive answer on these problems.

To be convinced in it, arithmetic and logic operations universally we represent through physical quantities and their transformations, (i. e., through characters Lₚ). Their algorithms in the language Lₚ look like arithmetic and logic operations. Their algorithms on the language Lₚ look like:

\[
\begin{align*}
  x + y + \eta &= \langle K \langle K \langle h \langle Ix, Iy, I_2\eta \rangle, K \langle Ix, Iy, I_2\eta \rangle, K \langle x, y, \eta \rangle \rangle, S \langle x, y, \eta \rangle \rangle \rangle, \\
  x - y &= \langle IK \langle K \langle Ix, Iy \rangle, K \langle Ix, y \rangle, S \langle Ix, I_2y \rangle \rangle \rangle, \\
  x \lor y &= IK \langle K \langle Ix, y \rangle, y \rangle, \\
  x \land y &= K \langle K \langle x, Iy \rangle, Iy \rangle.
\end{align*}
\]

The left parts of the formulas (8) and (9) present arithmetic and logic operations accordingly, and the extremely physical quantities and transformations figure in the right parts.

As with the help hₚ are representable only the ebi-mos of \( \sum_1^n C_i P^i \), where \( C_i \in hₚ \) that multiplying (and dividing) it is possible to reduce to repeated (\( \sum_1^n C_i \) of time) totings (deductions). In (8) \( \eta \) there is transferred unit, that is convenient for applying in computers. If to put \( \eta \equiv 0 \), we shall receive algorithm of the sum of two numbers. The definitions (9) provide distributivity of the physical logicians on the basis of Lₚ. It is possible to define them in another way and to receive another logician on Lₚ, including non distributivity. The formulas (8) and (9) give an example of physical models, arithmetic and logic operations, and if the algorithms of calculus to translate into the language Lₚ, so the calculus will be physical, and the realizing machine will be the physical computer.

The element base for such machines, i.e. all the five basic polistors is possible to realize on the basis of electron-hole plasma, the mathematical model, each of which is possible to present as a systems from P (model) of different bistable subsystems [18]

\[
  j = \hat{i}_k x_k + \hat{j}_k \delta_k \sqrt{x_k} + \hat{i}_k \hat{\beta}_{k+1} x_{k+1} - \hat{j}_k^y,
\]  

(10)
\[ j(1 - \beta_{k+2}) = \hat{\beta}_{k+1} x_k + \varphi_{k+1}(v_{k+1}) + \hat{i}_{k+1} x_{k+1}. \]

(11)

Where \( x_k = (-1)^k \left(1 - e^{(1-k+1)\frac{\epsilon}{T}}\right) \) and by \( \hat{j}_y^k, \hat{i}_k, \delta_k, \hat{\beta}_k \) are denote densities of management and saturation currents \( j_y \), \( \delta \), and particles transport \( \beta \) accordingly, with account Plasma-field interaction effect (PFIE) [18-19]

The outcomes, obtained in activities, and theorems allow to establish not only existence of many solved problems (10) - (11) for all polistors \( L_p \) with properties (4) - (7), but also to select the solution ensuring a processing compatibility of integral fulfillment of polistors in all five types.

This purpose for electron-hole plasma (EHP) is reached extremely due to operating EPPB in it.

**Conclusion and discussion**

Consideration in the previous section of the elementary models PS-multistable EHP, allows to conclude, that, apart from other physical quantities, the logical expression is also the quantitative characteristic of a system condition which is capable to participate in different interplays in it and to be converted. Thus in number with energy, entropy etc. definite quantities of the internal latent information and logicians capable partially to be used in information and computation process inherent in physical systems. In certain conditions resources latent the logicians can be sufficient for construction selfcontained and full, for the given purpose, physical logical system, most elementary of which one is \( L_p \). Determined \( L_p \) can become the basis for realization of physical calculus and physical computers. More effective example of physical calculus, are the quantum calculus, marked in section, and computers, in which one will be used latent indeterminated of the logician for organization of parallel calculus. The essential difference \( L_p \) and quantum computers is, that the physical calculus without mathematical and logic operations in a nonclassical logical system is in case of the former made, and in the second case the mathematical calculus in a classic logical system with usage of quantum algorithms is made, i.e. the logical fundamentals of organization of calculus is changed.

The logical properties PS allow to combine these two ways. For \( L_p \) this purpose is possible to reach by several images. Most primitive in this schedule, would be usage of neuronic calculus in the neuronic architecture, since polistor \( L_p \) are physical neurons, as against programmatic or hardware neurons.

Other capabilities are connected either to the extension \( L_p \) up to the quantum logicians, or with quantum - correlated combination of several \( L_p \).

All these cases are grounded on latent logician and on its physical nature.
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