Statistical Approach to the Representation of Clinically Observed Organism States as Observables of the Heisenberg Quantum-Mechanical Formalism

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Mathematical model, that allows to define the state of human organism according to cytochemical data, is offered. So taken into account the concept of organism as a quantum system, the measurement of each index is connected with linear operator in multidimensional states space. The statistical approach to the definition of diagonal representation of these operators is found. The changes of organism state on different stages of Microwave Resonance Therapy (MRT) treatment are observed by means of the offered model on example of patient's group with immunodeficiency. One can represent the states changes as the trajectory in the introduced space of variables. These trajectories are associated with peculiarity ("cathastrophe") of pleat type. In cases of improvement of patients' clinical condition, the trajectories move states into lower dimensions subspace.

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In this paper an approach to the definition and representation of clinically observed states of organism is considered. These states are found out by the observations on the set of indexes measured in clinical conditions dynamics.

1. The initial point of suggested approach is the idea developed by physics of the alive about organism's integrity as a quantum-physical system. Under this approach the system of measured indexes is considered as a system of observables in the meaning of quantum physics and organism states are expressed via corresponding state-vectors of this system. The clinical observations done on different stages of use of MRT-technology of treatment serve the empirical background of performed researches. The revealed holistic character of MRT-methods' action on organism allowed to pose a problem of this integrity representation.

A matrix approach to quantum systems' investigation and its interpretation in terms of statistical means of experimental data analysis, especially the methods of factor analysis makes up the formal logic of organism's states-vectors definition according to measurable indexes. Within limits of these interpretations the organism state is determined by limited sets of two or three latent (not observed directly) parameters (LP).

In coordinates of induced space LP organism's state is found out within the area of some point which location is calculated according to measured set of indexes (in our example it is the set of organism's immune state indexes). By accompanying the treatment with definite consequence of such measurements we can observe in LP coordinates the organism transi-

tions from state BEFORE to state AFTER action that are displayed as possible transition states for organism.

2. The model of indexes system's measurement. In initial approach to the organism's state is specified in experimental table OBJECTS×PARAMETERS type. This ($N \times M$) matrix A is considered at different stages of analysis either N rows (M-dimension vectors representing N objects) or M columns (N-dimension vectors representing M parameters).

For example, the influence of MRT on cytochemical indexes' set found its representation in the tables of 11 indexes' set of 43 patients immune status – BEFORE and AFTER action.

3. The computing scheme of representation of organism state according to experimental table (matrix A) is built on the background of Koryne-Loev decomposition of appropriate correlative matrix R. From statistical point of view these are the methods of factor analysis in the main components model [1] but we must stress the algebraical more than statistical nature of used representation.

Matrix A [N, M] is normalized so that

$$A' \times A = R[N, M];$$

$$|R_{i,j}| \le 1 \text{ where } i \ne j;\ R_{i,j}=1 \text{ where } i=j \tag{3.1}$$

where $R_{i,j}$ are correlation coefficients between i and j indexes; × is matrix multiplication; A' is transponated matrix A.

The matrix R [M, M] is decomposed on its self vectors according to its self values.

$$R = L1(V1 \times V1') + L2(V2 \times V2') + ... + LK(VK \times VK') =$$

$$= F1 \times F1' + F2 \times F2' + ... FK \times FK,\ K \le M; \tag{3.2}$$

where $L1$, $L2$, ... are self numbers of positively defined operator R, i.e., positive and ordered so that $L1 > L2 > ...$ is specter of decomposition; $V1$, $V2$, ... are corresponding self vectors normalized so that the square of their lines is equal to 1; $F1 = |\sqrt{L1}|V1$, $F2 = |\sqrt{L2}|V2$, ... are vectors defining the new coordinate system – the factor structure.

$$F(M, K) = [F1, F2, ... FK]; \tag{3.3}$$

The coordinates of matrix A rows are to be calculated in built basis F, i.e., the objects' coordinates in new basis.

$$Z(N, K) = A \times F'; \tag{3.4}$$

4. The considered L, F, Z representations of experimental data matrix A have many useful characteristics:

4.1. L allows to estimate the space dimension, containing the points (objects) and vectors (indexes) – the enclosed dimension. In the analysis of dynamic systems it means the enclosed attractor dimension [2]. In terms of statistics the dimension is a total dispersion contribution

$$D(s) = L1 + L2 ... + LS)/\text{trac}(R),$$

which the first S components describe, trac is a matrix trac that in our case is equal to M – the dimension of observations' space.

4.2. If the observation's table is connected with dynamic process then $F1$ is the order parameter and $L1$ is a significance level (contribution) of order parameter [3].

4.3. The objects A vectors' projections on subspace F reflect the best mutual arrangement of points toward all the possible subspaces of K dimension (from point of view of MNK-estimations), i.e., the points located close from each other remain comparatively close from each other on their projections, and, respectively, the points located far from each other remain comparatively far from each other in their projections. (They are close or far according to Euklid metrix) [4].

4.4. The increase of $L1$ means the decrease of stability (in terms of R matrix caution) for occasionally chosen vector between all possible directions and the increase of stability toward the direction $F1$.

5. The observation for the organism states BEFORE and AFTER action on different patients groups (of different nosologies) for different sets (systems) 9 of indexes allows us to make a principally significant conclusion of the total effect of treatment.

The enclosed dimension of states space reduces after treatment, but that is the same, the first components' contributions in observed total dispersion of possible states increase.

Table 1. Specter of enclosed dimensions of L-decomposition for subspaces of parameters' space by 11 cytochemical indexes

Before treatment				After treatment		
$L1$	$L2$	$L3$		$L1$	$L2$	$L3$
			Group 1 (Inf)			
3.58	2.84	1.73	L	5.15	2.63	1.44
32.6	25.8	15.72	%	46.8	23.9	13.1
	$D(1)$=58.4%				D(2)=70.7%	
			Group 2 (MRT)			
3.99	3.00	2.39	L	6.23	2.03	1.24
36.3	27.6	21.8	%	56.7	18.5	11.3
	$D(1)$=53.9%				$D(2)$=75.2%	
			Group 3 (MRT+inf)			
5.02	1.99	1.55	L	5.51	3.25	0.99
45.6	18.1	14.1	%	50.0	29.5	9.0
	$D(1)$=63.3%				$D(2)$=79.5%	

In Table 1 the typical display of this effect on series of observations for cytochemical indexes on children's groups following strenghtening immune system treatment is shown. It is typical that in comparative series of experiments this effect is expressed more distinctly during the MRT-action. (Compare $D(1)$ and $D(2)$ of groups 1 and 2 that initial states are similar).

The discovered effect has synergetic interpretation. Under this interpretation the organism state according to some observables system may be characterized with the enclosed subspace it occupies in introduced representation.

The different states may have varied dimension but besides there is convicting evidence of the fact that "the more healthy" organism state is characterized by reduce of dimension. We can observe the increase of order parameters' contribution $L1$ (see [3]) in total dispersion (fluctuation), i.e., the increase of organization and synchronization in system dynamics. The decrease of dimension means also potential possibility of the introduction of simpler states description in terms of necessary equations numbers. So the larger sets of observed indexes (measurements) representing the organism states may be described with small number of parameters. Revealed effect gives an argument in favor of significant physical status of introduced coordinates system, not only the convenient way of data representation. It allows to come to definition of organism state as a vector of quantum-physical state and to represent the measurable parameters as observable matrix elements defined toward two different states [5], i.e., connected with transition state.

6. Transition from one state to another is described with the help of the same computing scheme represented in point 3. By joining in different way the matrixes of initial observations A and B we can build (calculate) the less possible vector space for dimension in which the different sides of transition from one state to another are reflected in the most statistically informative way.

$$C1 = \begin{bmatrix} A \\ B \end{bmatrix} \tag{6.1}$$

– the rows' joining of matrixes A and B. In this matrix each object (row) is represented twice – before action (row i) and after action (row $i+N$). By using the above mentioned scheme 3 to this matrix we can calculate the phase space F; Join the projections of points i and $i+N$ on this space segment with straight line; This segment we can interpret as a linear replacement of the trajectory transitions' part of object i from state A to state B.

$$C2 = [A, B] \tag{6.2}$$

– the columns joining of matrixes A and B. In this table we can differ the columns j and $j+M$ – the indexes before and after action. In projection on F owing to the angle between the projections of vectors j and $j+M$ we can judge about its influence on some parameter.

$$C3 = \begin{bmatrix} A, B \\ B, A \end{bmatrix}. \tag{6.3}$$

The matrix is constructed so that it allows to reflect the symmetry and its disturbances during the transitions from A to B and from B to A:

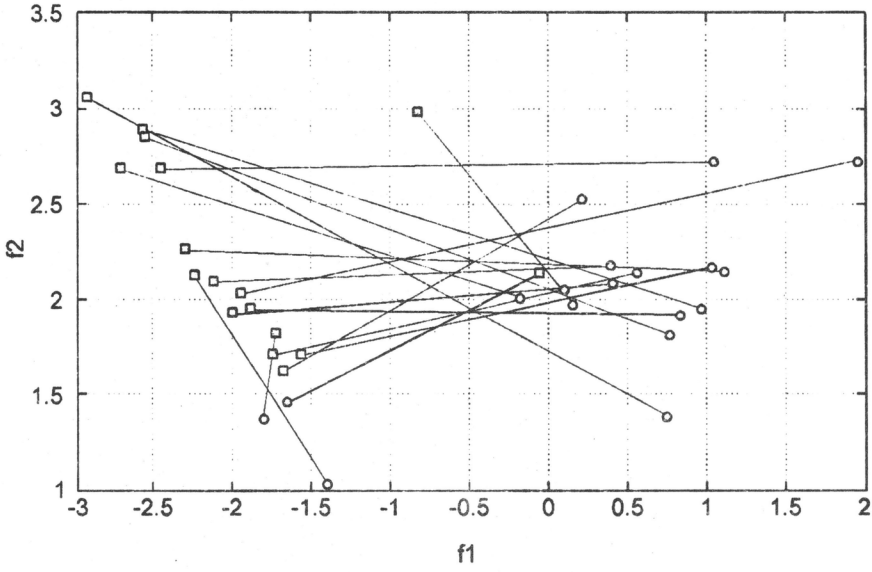

Fig. 1 Factor meanings of transitions
○ – state before treatment
▨ – state after MRT-action

7. There are enough experimental data to conclude that for monotonous (in terms of self variation characteristics) sets of indexes according to scheme (6.1) we can introduce the transition of F-representation in which the effect of decrease of enclosed space dimension retains (is observed). Thus, for example, for a group of 11 cytochemical indexes according to observations for the course of strenghtening the children's immune system by interferon, MRT, MRT+interferon action the *F*-representation interpreted as matrix representation of observed system was calculated (Table 2).

Table 2. *F*-representation of set of cytochemical indexes

	Cytochemical indexes	*F1*	*F2*	*F3*
1.	T-lymphocytes	0.219	0.382	0.042
2.	B-lymphocytes	-0.170	0.264	0.002
3.	O-lymphocytes	-0.035	-0.516	-0.037
4.	SDG of T-lymphocytes	0.236	0.230	0.551
5.	DNA	0.177	0.357	-0.476
6.	B-activated cells	-0.415	0.175	0.079
7.	SDG of T-helpers	0.190	0.318	0.474
8.	SDG of B-activated cells	-0.421	0.153	0.047
9.	Acid phosphatase of B-activated cells	-0.449	0.185	0.018
10.	T-helpers DNA	0.187	0.345	-0.483
11.	B-activated cells DNA	-0.461	0.173	-0.011
	L:	3.869	2.238	1.745
	%	35.18	20.35	15.87
		D(2)=55.5		

The components of F-representation are the correlation coefficients between the observables and factor projections of state-vector (the proper numbers of operators of observed value are in basic and factor states).

The fact of existence of global coordinates for the organism states' representation as the quantum system giving the transition in which local changes of enclosed dimensions are safe isn't trivial at all. The introduced coordinates allow to describe (observe) the dynamics of states changes formally.

On Fig. 1 the transition trajectories from state BEFORE to state AFTER the straightening of immune system (health improvement) by MRT+interferon methods are shown. It is typical that the initial "scattered" on surface state is converting in line. In addition if the initial state is placed on this "attracting" line then the movement occurs similarly along this line (two cases on Fig. 1). The cases of alternate movement happen very seldom if the state with attractive line is breaking into the area of initially "bad" state (one case on Fig. 1).

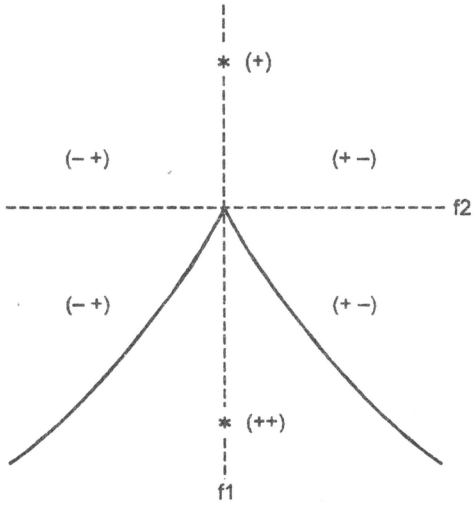

Fig. 2 Scheme of areas corresponding to different types of potential functions' arrangement on $f1$ and $f2$ planes

one minimum		+
left degenerating minimum and minimum	–	+
right degenerating minimum and minimum	+	–
two minimums	+	+

8. We have settled earlier that there are theoretical presuppositions and experimental support of the fact that in introduced according to (6.1) scheme the phase plane of transition trajectory from state BEFORE to state AFTER treatment is connected with display on the plane of one of two-dimensional variety projections' peculiarities (in catastrophe theory these are the catastrophes of pleat type) in three-dimensional space ($f1$,$f2$,X) and set by dissolving of equality and turn angle is determined in regard of statistics

$$F = X^3 + f1\,X + f2 = 0;$$

where $f1$ and $f2$ are the orthogonally converted $F1$ and $F2$.

In catastrophe theory F is considered as a gradient of function family depending on two manager parameters ($f1$, f2).

The present statistical data allow to suppose that the movement trajectories belong to this variety (are lying in this variety). If this assuming is true the segments of trajectories may be considered as linear function of pleat type catastrophe on planes $F1$ and $F2$ [6].

On Fig. 2 the corresponding to pleat scheme of areas' arrangement on $f1$ or $f2$ planes is represented by different types of minimums and maximums of potential functions.

The following situations are substantial for us:
(besides the point of trefoil degeneracy and (0,0) and separatisse line)

one minimum M		+
left degenerating minimum and minimum	–	+
right degenerating minimum and minimum	+	–
two minimums	+	+

These cases divide the area of possible organism states into areas of different character of this states' stability.

On Fig. 3 the scheme of mutual correspondence of planes $F1 \times F2$ and pleat catastrophe is shown.

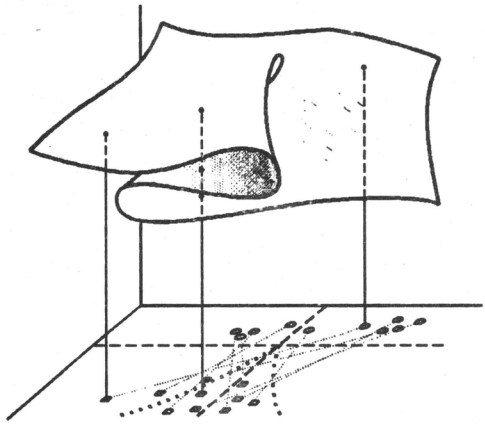

Fig. 3 Scheme of mutual arrangement of pleat and space representing the transitions

The effects discovered in such a way allow us to interpret the healthy state of organism as some pure quantum state and the violated state as some mixed quantum state.

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The introduced system of latent variables allows to come to investigation of organism as quantum-physical system and is able at least qualitatively to define the connection of representation of clinical measurements as observed and organism state as a state-vector with other facts of organism quantum-physical nature displaying.

The transition from scalar measured values to operator in linear space of states was earlier offered by Heisenberg following his creation of matrix formalism of quantum mechanics. The statistical approach suggested here is essentially a numerical method of operators diagonal representation discovery, measured organism's indexes and allow to use practically the Heisenberg's matrix formalism just before the discovery and research of evident equations of movement.

To summarize we want to estimate the medical favor of built latent variables' system. This system:

- is statistically steadily displayed in variety of researches on patients of different nosologies. This allows to introduce an idea about not only the value intervals (for norm and pathology) of measured indexes but also of their combinations;
- finds out the areas for norm and possible trajectories for norm achievement, if this norm is violated. This allows to prescript from some moment the possible effects on organism of fixed technics of treatment;
- determines the structure of areas for states. In terms of introduced LP the areas characteristic for organism states are connected with norm disturbance and the areas characteristic for different stages of organism treatment are determinated. The enclosed dimension occurred to be the essential feature of these areas that decrease during the transition toward the areas connected with norm (from dimension 2-3 to dimension close to 1), i.e., in terms of introduced representation the normal state differs the higher coordination of dynamic processes;
- determines the trajectories' structure for transitions from one state to another. These trajectories or more exactly their linear approximations are associated with the surface determined in catastrophe theory as pleat catastrophe. So the direction of the transition may be interpreted as the transition from methastable states to the area of stable states.

КЛІНІЧНІ ХАРАКТЕРИСТИКИ СТАНУ ОРГАНІЗМУ ЯК СПОСТЕРЕЖУВАНІ В МАТРИЧНОМУ ФОРМАЛІЗМІ ГАЙЗЕНБЕРГА

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Пропонується математична модель, яка дає змогу визначити стан організму людини за набором цитохімічних показників. При цьому, виходячи з уявлень про організм, як про квантову систему, вимір кожного з показників пов'язується з лінійним оператором у багатомірному просторі станів. Знайдено статистичний підхід до визначення діагонального представлення цих операторів.

На прикладі групи пацієнтів з імунодефіцитом засобами запропонованої моделі розглянуті зміни у стані організму на різних етапах лікування МРТ. Виявлено, що зміну станів можна показати траекторією у введеному просторі перемінних. Ці траекторії асоційовані з особливістю ("катастрофою") типу складання. У випадках покращення клінічного стану пацієнтів траекторії переводять стани в підпростір меншої розмірності.

КЛИНИЧЕСКИЕ ХАРАКТЕРИСТИКИ СОСТОЯНИЯ ОРГАНИЗМА КАК НАБЛЮДАЕМЫЕ В МАТРИЧНОМ ФОРМАЛИЗМЕ ГАЙЗЕНБЕРГА

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Предлагается математическая модель, позволяющая определить состояние организма человека по набору цитохимических показателей. При этом, исходя из представлений об организме, как

о квантовой системе, измерение каждого из показателей связывается с линейным оператором в многомерном пространстве состояний. Найден статистический подход к определению диагонального представления этих операторов.

На примере группы пациентов с иммунодефицитом средствами предложенной модели рассматриваются изменения состояния организма на различных этапах лечения методом МРТ. Обнаружено, что изменение состояний можно представить траекторией во введенном пространстве переменных. Эти траектории ассоциированы с особенностью ("катастрофой") типа сборки. В случаях улучшения клинического состояния пациентов траектории переводят состояния в подпространство меньшей размерности.

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