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ON THE IMPOSSIBILITY OF CREATING THE QUANTUM CORRELATIONS WITH COMPUTER

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1. INTRODUCTION

R.P.Feynman in his work "Simulating Physics with Computers"[1] has introduced the correlations of two photons in singlet state as an example of the fact that assumption about the existence of the definite projections of the photon's linear polarizations on different directions contradicts the quantum mechanical results.

The aim of our paper is to indicate that Feynman's proof can be interpreted in another way if the general transformations of the probability measure of the treated systems do not form a group.

We shall start with a model of the singlet systems, described with the help of the relative measure of the probability on the concave surfaces[2]. In such model it is possible to form only the cyclic group of transformations and with the proper handling with probabilities the contradiction with quantum mechanics does not arise.

The plan of our exposition is the following: in Sec.2 we briefly recapitulate Feynman's reasoning, in Sec.3 we present the essential features of the models with relative probability measure and in Sec.4 we analyse Feynman's proof. The closing section is devoted to more general comments on the subject.

2. THE FEYNMAN PROOF

R.P.Feynman in his consideration deals with the problem of modelling of the physical phenomena with computers. The stochastic correlations of two subsystems can be realized in a way as it is demonstrated on Fig.1. We use the notations as in the usual scheme of the local hidden variables formulated by J.S.Bell[3].

$$P(\vec{a}, \vec{b}) = \int A(\vec{a}, \lambda)B(\vec{b}, \lambda)\rho(\lambda)d\lambda. \tag{1}$$

Here $P(\vec{a}, \vec{b})$ denotes the correlation function, $A(\vec{a}, \lambda)$ and $B(\vec{b}, \lambda)$ are the experimental results referring to the partic-

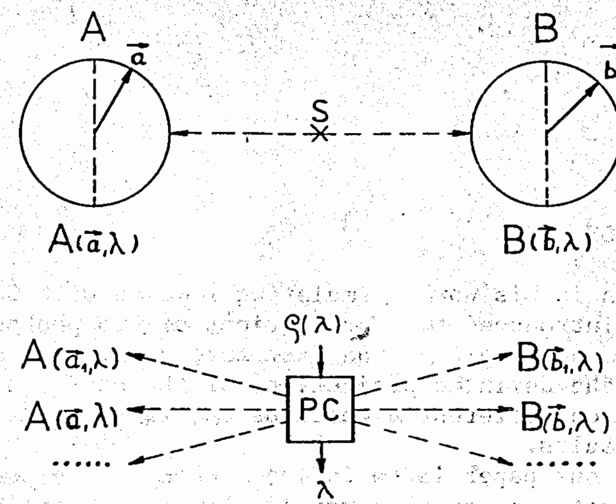

Fig.1. Modelling of the stochastic correlations of two subsystems with a computer. The meaning of the symbols used is explained in the text

les "1" and "2" measured by apparatus A oriented along the direction $\vec{a}$ and by apparatus B oriented along the direction $\vec{b}$, $\rho(\lambda)$ is a normalized probability measure.

The operation of a computer in the stochastic model can be imagined in the following manner: PC generates by chance a numbers - the values of λ - with the frequencies corresponding to the probability measure $\rho(\lambda)$, which completely determines both subsystems, e.g. particles "1" and "2". The measurements of the particle's characteristics on the apparatuses A and B are given by certain computing procedure for evaluating $A(\vec{a}, \lambda)$ and $B(\vec{b}, \lambda)$.

Due to the succession of events (the considered subsystems firstly come to being and only then the measuring is performed) it is possible to make the choice of $\vec{a}$ and $\vec{b}$ arbitrarily and independently. This fact has a logical consequence: there must exist the definite values of functions $A(\vec{a}, \lambda)$ and $B(\vec{b},\lambda)$ for each pair and for any choice of directions $\vec{a}$ and $\vec{b}$. As it is indicated in Feynman's consideration, it is the main reason why such a scheme contradicts the quantum mechanical results.

R.P.Feynman in his paper has considered the singlet two-photon system, which can be described quantum-mechanically as

$$\Psi(1, 2) = \frac{1}{\sqrt{2}} \{(1)_x (2)_x + (1)_y (2)_y\}, \quad (2)$$

here the indices x and y describe the linear polarization along the corresponding axis.

Using (1) we shall denote the values of $A(\vec{a}, \lambda)$ and $B(\vec{b}, \lambda)$ as +1 if the linear polarization will be directed along the corresponding axis and as -1 in the case of the perpendicular orientation.

We remark here that because of the symmetry of the wave function (2) it must hold

$$A(\vec{a}, \lambda) = B(\vec{a}, \lambda), \quad (3)$$

for arbitrary $\vec{a}$ and λ, and also

$$A(\vec{a}, \lambda) = -B(\vec{b}, \lambda), \quad (4)$$

for each λ and $\vec{a} \perp \vec{b}$.

The expressions (3) and (4) can be combined as

$$A(\vec{a}, \lambda) = -A(\vec{b}, \lambda), \qquad B(\vec{a}, \lambda) = -B(\vec{b}, \lambda), \quad (5)$$

for perpendicular $\vec{a}$ and $\vec{b}$.

In Secs.3 and 4 we shall also use the consequence of the rotational invariance of (2)

$$P(\vec{a}, \vec{b}) = P(\phi_{ab}). \quad (6)$$

The Feynman reasoning can be expressed in the following way. Due to the strong correlations between the projections of the linear polarizations of both paired photons (3) the results of measuring of $A(\vec{a}, \lambda)$ and $B(\vec{b}, \lambda)$ will be the same for parallel orientations of both apparatuses. There arises a typical situation for EPR correlations /4/: measuring property of one particle makes possible to predict value of the second one.

Let us suppose that there exist definite values of $A(\vec{a}, \lambda)$ and $B(\vec{b}, \lambda)$ for each pair ($\vec{a}$, $\vec{b}$ are arbitrary) and let us try to estimate the probability of getting the same result on both apparatuses i.e. (+1, +1) or (-1, -1), when $\phi_{ab} = 30°$.

We can proceed in the following way. Let us consider firstly projections of one pair onto different directions for parallel orientations $\vec{a}$ and $\vec{b}$. The example of such hypothetical measurement is presented in Fig.2, where the angle 30° between neighbouring vectors was chosen.

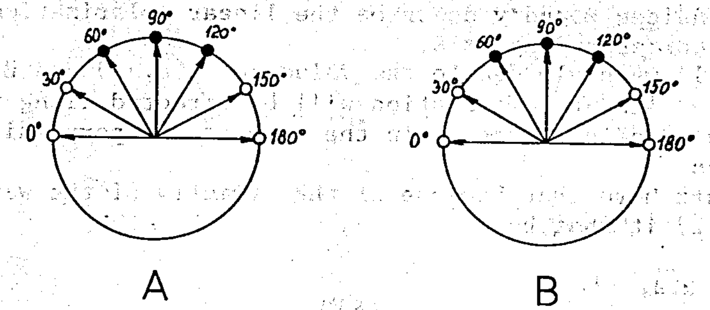

Fig.2. The measuring of the projections of one pair onto different directions of parallel $\vec{a}$ and $\vec{b}$. Notations: o - $A(\vec{a}, \lambda)$, $B(\vec{b}, \lambda) = +1$, • - $A(\vec{a}, \lambda)$, $B(\vec{b}, \lambda) = -1$.

Repeating the experiment with other pairs of photons we shall receive the different sequences of o and • at angles 0°, 30° and 60°, while the rest of values will be determined according to (5). In Fig.2 this feature is taken into account.

The probability of getting the same results on both the apparatuses A and B ≡ $W(\phi_{ab} = 30°; A(\vec{a}, \lambda)\cdot B(\vec{b}, \lambda) = +1)$ is equal to the fraction of preferred events to the sum of all possibilities.

From the inspection of Fig.2 it is evident that we can consider equal or different results on one apparatus at orientations $\phi_2 - \phi_1 = 30°$. The possible sequences and corresponding probabilities are presented in Table 1.

Table 1. The possible sequences of $A(\vec{a}, \lambda)$ measured on A. Remaining possibilities (5 - 8) give the same values of W for o ↔ •

Seq.	0°	30°	60°	90°	120°	150°	180°	W
	$\vec{a}_0$	$\vec{a}_1$	$\vec{a}_2$	$\vec{a}_3$	$\vec{a}_4$	$\vec{a}_5$	$\vec{a}_6$	
1	○	○	○	●	●	●	○	2/3
2	○	○	●	●	●	○	○	2/3
3	○	●	○	●	○	●	○	0
4	○	●	●	●	○	○	○	2/3

From this Table it follows that

$$0 \le W(\phi_{ab} = 30°; A(\vec{a},\lambda)\cdot B(\vec{b},\lambda) = +1) \le 2/3. \quad (7)$$

This result contradicts the quantum mechanical value of W, as far as here $W = \cos^2 30° = 3/4$.

R.P.Feynman has concluded his reasoning: "That's all. That's why quantum mechanics can't seem to be imitable by a local classical computer".

As we have declared in the Introduction we want to propose another possible interpretation of the mentioned contradiction. For that we shall briefly recapitulate the main features of the model with relative probability measure /2/ in the next Section.

3. RELATIVE MEASURE OF PROBABILITY ON THE CONCAVE SURFACE AS A MODEL OF THE PHOTON LINEAR POLARIZATION

In our preceding paper we have considered a model of the singlet state of two photons or two particles with spin s = = 1/2. We have described such systems with the relative probability measure on the concave surfaces. The formulation of this model was motivated by the investigation of the Bell inequalities in the metric form. A conjecture was proposed that the conflict between quantum mechanics and Bell inequalities can be understood as a manifestation of non-metricity of the hidden variable space. This hypothetical non-metric space can be identified at least at one point with the metric space of the relative probability measure and therefore only the restricted triangulation of the mentioned space can be realized. As a consequence it follows that we can relate the probability measure to definite frame of reference and the conception of the absolute (independent) probability measure must be abandoned.

The relative probability measure makes possible to evaluate the correlations through reference frame of apparatus A as

$$P_{\vec{a}}(\vec{a}, \vec{b}) = \int A(\vec{a}, \lambda)B(\vec{b}, \lambda)\rho_{\vec{a}}(\lambda)d\lambda, \quad (8)$$

or through the reference frame of the apparatus B as

$$P_{\vec{b}}(a, b) = \int A(a,\lambda)B(b,\lambda)\rho_{\vec{b}}(\lambda)d\lambda. \quad (9)$$

Here $\rho_{\vec{a}}(\lambda)$ and $\rho_{\vec{b}}(\lambda)$ are normalized relative probability measures.

Such a formulation permits one to satisfy the rotational invariance

$$P_{\vec{a}}(\vec{a},\vec{b}) = P_{\vec{b}}(\vec{a},\vec{b}) = P(\phi_{ab}), \qquad (10)$$

for discrete values of $A(\vec{a}, \lambda)$ and $B(\vec{b}, \lambda)$.

It is possible to restore the quantum mechanical results on the basis of eq.(8) using the following relations

$$A(\vec{a}, \lambda) = \text{sign}\{\cos 2\phi_{a\lambda}\},$$
$$B(\vec{b}, \lambda) = \text{sign}\{\cos 2\phi_{b\lambda}\}. \qquad (11)$$

The probability measure of the photon singlet is described as a system of vectors $\vec{\lambda}$ with beginnings in the centre and their ends distributed on the circle (such measure can be presented as a measure on the concave surface - see preceding paper)

$$\rho_{\vec{a}}(\lambda)d\lambda = \frac{1}{4}\,|\sin 2\phi|d\phi,$$
$$0 \le \phi \le 2\pi;\ \phi_a = \frac{\pi}{4}. \qquad (12)$$

Using (9) we must replace $\vec{a}$ by $\vec{b}$ in (12).

Remark in addition that rules (11) ensure that each photon has a definite projection of linear polarization onto different directions and that conditions (3)-(5) are also satisfied.

Now we want to discuss in some detail the transformations of $\rho_{\vec{a}}$. Firstly we shall search for the relation between $\rho_{\vec{a}} \rightleftarrows \rho_{\vec{b}}$, where $\rho_{\vec{a}}$ relates to the particle "1"; and $\rho_{\vec{b}}$, to "2", which corresponds to the connection between frames of reference $A(\vec{a})$ and $B(\vec{b})$.

For the sake of brevity we shall denote the relative probability measure as $\rho_{\vec{a}}(\lambda_a)$ and $\rho_{\vec{b}}(\lambda_b)$. We shall try to find a procedure which relates $\rho_{\vec{a}}$ and $\rho_{\vec{b}}$ for one definite experimental set

$$\rho_{\vec{b}}(\lambda_b) = \hat{R}(\phi_{ab})\rho_{\vec{a}}(\lambda_a). \qquad (13)$$

In our preceding paper [2] we have inferred the properties of $\hat{R}(\phi_{ab})$ on the basis of the following natural requirements.

A_1. The equivalence of the reference frames related to apparatuses A and B: the function $\rho_{\vec{a}}$ must have a covariant form, i.e., $\rho_{\vec{a}}$ must be the same function of λ_a as it is $\rho_{\vec{b}}$ with respect to λ_b.

A_2. The invariance of each event: each experimental event (+1, +1), (+1, -1), ... must be independent of the frame of reference used.

We point out that requirements A_1 and A_2 establish unambiguous relations $\lambda_a \leftrightarrow \lambda_b$ only for some values of ϕ_{ab}. For the full explicitness still another principle is needed. There can be used, e.g., the following one: small changes of ϕ_{ab} result in small changes of $\hat{R}(\phi_{ab})$. The discussed implications, however, do not depend on such specifications.

On Table 2 there are presented examples of the transformations $\rho_{\vec{a}} \leftrightarrow \rho_{\vec{b}}$ for some values of ϕ_{ab}. For simplicity we here used the discrete representation of hidden variables λ as before. It is supposed that procedure $\Delta\lambda \to 0$ can be used which may hide the discreteness used.

From Table 2 the following important properties of $\hat{R}(\phi_{ab})$ can be deduced.

P_1. In general, $\hat{R}(\phi_{ab})$ do not form a group.
Cf. the rows 2, 3 and the last one.

P_2. The transformations $\hat{R}(n\frac{\pi}{2})$ for $n = 0, 1, 2, \ldots$ form a cyclic group.
Cf. rows 1, 4 and 7.

P_3. For each ϕ_{ab} it holds $\hat{R}(\phi_{ab} + n\frac{\pi}{2}) = \hat{R}(\phi_{ab})\cdot\hat{R}(n\frac{\pi}{2})$.
Cf. rows 1, 2 and 3 with that of 4, 5 and 6.

Before discussing the consequences of P_1 - P_3 we recall here that up to now we interpreted $\hat{R}(\phi_{ab})$ as a transformation from one of the reference frames $\rho_{\vec{a}}$ (related to apparatus A measuring the particle "1") to $\rho_{\vec{b}}$ (related to apparatus B and measuring the particle "2"). The reversal transformation can be realized with $\{\hat{R}(\phi_{ab})\}^{-1}$ and, naturally

$$\hat{R}(\phi_{ab})\cdot\{\hat{R}(\phi_{ab})\}^{-1} = 1. \qquad (14)$$

It is evident, however, that because of the symmetry between particle "1" and "2" the transformations of the same reference frame (say A)

Table 2. Examples of the transformations $\rho_{\vec{b}}(\lambda_a) = \hat{R}(\phi_{ab})\rho_{\vec{a}}(\lambda_a)$ for some values of ϕ_{ab}. The placement of $\vec{a}$ and $\vec{b}$ and the relative frequencies of boxes are defined in accord with (12). The positions of λ_b in the traced squares are determined unambiguously

Seq	φ_{ab}																
$\rho_{\vec{a}}$ (λ_a: 0, π/4, π/2, 3π/4, π)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2	π/8	8	7	3	4	5	6	10	9	16	15	11	12	13	14	2	1
3	π/4	8	7	6	5	12	11	10	9	16	15	14	13	4	3	2	1
4	π/2	9	10	11	12	13	14	15	16	1	2	3	4	5	6	7	8
5	5π/8	16	15	11	12	13	14	2	1	8	7	3	4	5	6	10	9
6	3π/4	16	15	14	13	4	3	2	1	8	7	6	5	12	11	10	9
7	π	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
$\hat{R}(\frac{\pi}{8})\cdot\hat{R}(\frac{\pi}{8})$		9	10	3	4	5	6	15	16	1	2	11	12	13	14	7	8

($\rho_{\vec{b}}$; λ_b: 0, π/4, π/2, 3π/4, π)

$$\rho_{\vec{a}'}(\lambda_{a'}) = \hat{R}(\phi_{aa'})\rho_{\vec{a}}(\lambda_a), \qquad (15)$$

will have the same properties as the transformations defined by (13). We do not especially discuss the transformations (15) here, as a far as its physical meaning can be understood only on the base of (13).

From the group characteristics of $\hat{R}(\phi_{ab})$ it follows that general expression $P_{\vec{n}}(\vec{a}, \vec{b})$ does not fulfile the conditions of rotational invariance (10) and therefore it cannot be treated as a correlation function. The reason for this behaviour follows from the fact that the transformations of $A(\vec{a}, \lambda)$ and

$B(\vec{b}, \lambda)$ form the rotational group, while the general transformations of $\rho_{\vec{n}}$ do not have this property.

Actually, using (11) and (12) one can show that expression $P_{\vec{n}}(\vec{a}, \vec{b})$ depends in general on the relative order and orientations of all three vectors; e.g. for vectors $\vec{n}$, $\vec{a}$ and $\vec{b}$, $\phi_{nb} < \frac{\pi}{4}$ we have

$$P_{\vec{n}}(\vec{a}, \vec{b}) = 1 - \cos 2\phi_{na} + \cos 2\phi_{nb}. \qquad (16)$$

In our model the "true" correlations are only those, which we have used in the definition

$$P_{true}(\vec{a}, \vec{b}) = P_{\vec{a}}(\vec{a}, \vec{b}) = P_{\vec{b}}(\vec{a}, \vec{b}),$$

or as it can be checked, those given by cyclic transformation $R(\frac{\pi}{2})$ of $\rho_{\vec{n}}$

$$P_{true}(\vec{a}, \vec{b}) = P_{\vec{n}}(\vec{a}, \vec{b}), \qquad (17)$$

where ϕ_{an} or ϕ_{bn} are equal to $n\frac{\pi}{2}$ $(n = 1, 2, \ldots)$.

After this preliminary comments we are ready to reconsider the Feynmann proof.

4. THE ANALYSIS OF THE FEYNMAN PROOF

The model presented in the preceding section is capable to restore the quantum mechanical correlations, and the rules (11) make it possible to assign the definite values of the projections to each photon. How to evaluate correctly the value of $W(\phi_{ab} = 30°;\ A(\vec{a}, \lambda)\cdot B(\vec{b}, \lambda) = +1)$?

Let us return for a moment to Fig.2 and Table 1. Due to the logic of the relative probability measure we can relate $\rho_{\vec{n}}$ only to one definite vector, let it be, e.g., $\vec{a}_1$. With such a relative measure we can describe the possible projections onto all vectors $\vec{b}_i$, but as a consequence of the limitations (11) we can treat as a quantum correlations $P(30°)$ only $P(\vec{a}_1, \vec{b}_0)$ and $P(\vec{a}_1, \vec{b}_2)$. The analogical situation arises when we choose another reference vector $\vec{a}_i$ or $\vec{b}_i$.

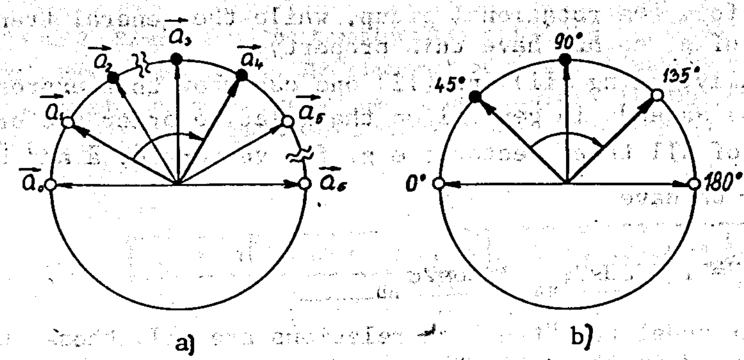

Fig.3. The example of projections of one paired photon onto different directions with the relative measure of the probability; a) $\Delta\phi = 30°$, b) $\Delta\phi = 45°$.

According to (17) we can use the cyclic transformation of $\rho_{\vec{n}}$, i.e., rotation about $\pi/2$ and then we receive the situation which is presented in Fig.3a.

Hence, it is evident, that for the evaluating the value of $W(\phi_{ab} = 30°;\ A(\vec{a}, \lambda)\cdot B(\vec{b},\lambda) = +1)$ we can use the same procedure as in Sec.2, but equal or different results received on one apparatus may be summed only on triads (i.e., for three neighbouring vectors).

Table 3. The possible sequences of $A(\vec{a}, \lambda)$ measured on A, corresponding to Fig.3a. Remaining possibilities (5 - 8) give the same values of W for o ↔ ●

Seq.	0^0	30^0	60^0	W
	$\vec{a}_0$	$\vec{a}_1$	$\vec{a}_2$	
1	○	○	○	1
2	○	○	●	1/2
3	○	●	○	0
4	●	○	○	1/2

Thus the properties of the relative probability measure produce a disintegration of the universal image represented by the absolute measure in the same way as in the case of the Bell inequalities (Cf. /2/).

The possible results obtained on triads of vectors are presented in Table 3.

The limitation which we get in this case

$$0 \le W(\phi_{ab} = 30°;\ A(\vec{a}, \lambda)\cdot B(\vec{b}, \lambda) = +1) \le 1, \qquad (18)$$

is trivial and does not contradict the quantum mechanical value.

As an example of the plausible exploitation of the cyclic tranmsformation the choice of value $\phi_{ab} = 45°$ can be presented. In this case it is possible to use the procedure indicated by Feynman without restriction (Cf. Fig.3b and Table 4).

Here we obtain for the value of W the unambiguous relation

$$W(\phi_{ab} = 45°;\ A(\vec{a}, \lambda)\cdot B(\vec{b}, \lambda) = +1) = \frac{1}{2}, \qquad (19)$$

which can be compared with the quantum mechanical value $\cos^2 45° = 1/2$.

Table 4. The possible sequences of $A(\vec{a}, \lambda)$ for $\Delta\phi = 45°$

Seq.	0^0	45^0	90^0	135^0	180^0	W
	$\vec{a}_0$	$\vec{a}_1$	$\vec{a}_2$	$\vec{a}_3$	$\vec{a}_4$	
1	○	○	●	●	○	1/2
2	○	●	●	○	○	1/2
3	●	●	○	○	●	1/2
4	●	○	○	●	●	1/2

In conclusion of the section we want to present a theorem about the maximum of the function $W(\phi_{ab};\ A(\vec{a},\lambda)\cdot B(\vec{b},\lambda) = +1)$ for which we shall use the shortened notation $W(\phi_{ab};\ A\cdot B = +1)$. This theorem is analogical to that which we have presented in the preceding paper[2]. It is possible in this way to demonstrate the inner consistency of our approach.

Theorem

The functions $P(\phi_{ab})$ and $W(\phi_{ab};\ A\cdot B = +1)$ reach their maxima for arbitrary $\rho(\lambda) > 0$ and ϕ_{ab} in the interval $0 \leq \phi_{ab} \leq \frac{\pi}{2}$ only if for each λ the sequence $A(\vec{a}_0,\lambda),\ A(\vec{a}_1,\lambda),\ \ldots\ A(\vec{a}_n,\lambda)$, $\phi_{a_0 a_n} \leq \frac{\pi}{2}$ changes its sign no more than once.

If the functions $\rho(\lambda)$, $A(\vec{a},\lambda)$ and $B(\vec{b},\lambda)$ guarantee the rotational invariance of $P(\vec{a},\vec{b})$ for any vectors $\vec{a}$ and $\vec{b}$, then the preceding condition is also sufficient and the maximal value of $P(\vec{a},\vec{b})$ is equal to

$$P(\vec{a},\vec{b}) = 1 - \frac{4\phi_{ab}}{\pi},$$

for ϕ_{ab} in the interval $0 \leq \phi_{ab} \leq \frac{\pi}{2}$.

We firstly indicate that the relation between $P(\vec{a},\vec{b})$ and $W(\phi_{ab};\ A\cdot B = +1)$ can be obtained from the evident equations

$$W(\phi_{ab};\ A\cdot B = +1) + W(\phi_{ab};\ A\cdot B = -1) = 1, \tag{20a}$$

and

$$W(\phi_{ab};\ A\cdot B = +1) - W(\phi_{ab};\ A\cdot B = -1) = P(\vec{a},\vec{b}). \tag{20b}$$

From (20) we have

$$W(\phi_{ab};\ A\cdot B = +1) = \frac{1}{2}\{1 + P(\phi_{ab})\} \tag{21}$$

From (21) it follows that maximal values of $P(\phi_{ab})$ and $W(\phi_{ab};\ A\cdot B = +1)$ will coincide for each ϕ_{ab}.

The meaning of the presented theorem and its motivation can be understood by the exploring Tables 1,3 and 4. We restrict ourselves only to a short commentary.

Table 1. Here the presented theorem can be applied in the full extent. The conditions of maximum are satisfied on the rows 1, 2 and 4. In the general case, when the interval 0° - 180° is divided onto n-subintervals (n even), we receive for W following values: $\frac{n-2}{n}, \frac{n-6}{n}, \ldots \frac{2}{n}$ (or 0). The value $\frac{n-2}{n}$ is maximal in accord with our theorem.

Table 3. Here only the first part of the theorem can be applied. Due to the prescriptions (11) and (12), the model used fulfils the conditions for the maxima of $P(\phi_{ab})$ and W and, therefore, the evaluation of W can be precisied (the 3rd row with W = 0 does not satisfy (11) and (12))

$$\frac{1}{2} \leq W(\phi_{ab} = 30°;\ A(\vec{a},\lambda)\cdot B(\vec{b},\lambda) = +1) \leq 1. \tag{22}$$

In our model of the relative measure both the variants W = 1 and W = 1/2 have equal weights and the correct quantum mechanical value of W is obtained.

Table 4. Here we met the analogic situation as in the case of Table 1. As far as the number of treated vectors is small, each sequence of $A(\vec{a},\lambda)$ satisfies the conditions of maximum. Moreover, the correct values of $P(\vec{a},\vec{b})$ and W follow directly from the conditions of symmetry (3) - (6)

$$P(\phi_{ab} = 45°) = 0,$$

and

$$W(\phi_{ab} = 45°;\ A(\vec{a},\lambda)\cdot B(\vec{b},\lambda) = +1) = \frac{1}{2}.$$

5. DISCUSSION

We incline to the opinion that the modelling of the quantum correlations with computers is possible. The price which we must pay for it - it is the necessity to abandon the concept of the absolute, independent probability measure.

In such a case the function of PC can be represented as it is done in Fig.4.

We suppose that each pair of correlated photons is described in the definite reference frame (A or B). Both frames are equivalent and their relation is defined through the transformation (13).

In the conclusion we consider a situation, when one or both apparatuses change their orientations during the experiment[5].

Let us study firstly the case when A is in the rest and B changes its orientation. Here it is natural to describe the singlet system with $\rho_{\vec{a}}$. We can use the preceding rules (11)

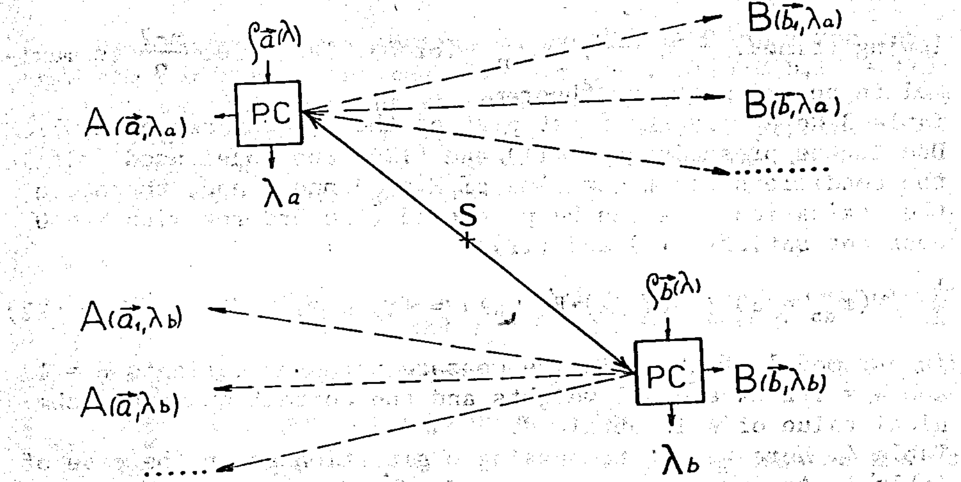

Fig.4. The modelling of the quantum correlations with a computer in the scheme of the relative probability measure

for evaluating $A(\vec{a}, \lambda)$ and $B(\vec{b}, \lambda)$, but now b depends on the time $\vec{b} = \vec{b}(t)$ and we must determine the value of $B(\vec{b}(t),\lambda)$ at the moment, when the particle "2" is interacting with the corresponding analyser.

Nevertheless, we shall obtain the same results, when we shall treat as a "rest references frame" - B with its $\rho_{\vec{b}}$. In this case $\vec{a} = \vec{a}(t)$ (the orientation of $\vec{a}$ is defined relative to the "rest" vector $\vec{b}$) and we must evaluate a value of $A(\vec{a}(t), \lambda)$ in such a moment when the particle "1" interacted with the corresponding analyser.

In general, when both the apparatuses change their orientations, we can also choice the "rest" reference frame as desired. The evaluation of $A(\vec{a}, \lambda)$ and $B(\vec{b}, \lambda)$ according to the rules (11) must be done in such a way that the mutual orientation of $\vec{a}$ and $\vec{b}$ will be equal to that which has taken both apparatuses when particles "1" and "2" interacted with corresponding analysers.

This permits one to understand received experimental results.

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