Article

Double-Slit Experiment and Quantum Theory Event-Probability Interpretation

Gunn Quznetsov*

Abstract

In this article the propagation of pointlike event probabilities in space is considered. Double-Slit experiment is described in detail. New interpretation of Quantum Theory is formulated.

Key words: Probability, propagator, quants, pointlike event.

Introduction

Ontology and interpretation of Quantum Mechanics are discussed from the thirties of the XX century [1] till present days [2]. A clear description of these basic interpretations is presented in the book by Anthony Sudbery [3].

I present another interpretation of Quantum Mechanics. This interpretation is based on newly-discovered fact that probabilities of pointlike events can be expressed by complex 4X1 matrix functions. And these functions obey equations which are similar to the Dirac's equations [4].

And here I evolve the idea of H. Bergson, A. N. Whitehead, M. Capek, E. C. Whipple jr., J. Jeans of presentation of elementary particles by events [5].

Propagation probability in space

Let[1] $\rho_A(x)$ be a probability density of a pointevent $A(x)$. And let real functions

$$u_{A,1}(\underline{x}), u_{A,1}(\underline{x}), u_{A,1}(\underline{x})$$

satisfy the following conditions:

$$u^2{}_{A,1}(\underline{x}) + u^2{}_{A,1}(\underline{x}) + u^2{}_{A,1}(\underline{x}) \leq \mathrm{c}^2,$$

and let if $j_{A;s} := \rho_A u_{A;s}$ then

$$\rho_A \to \rho_A^{'} = \frac{\rho_A - \frac{v}{\mathrm{c}^2} j_{A,k}}{\sqrt{1 - \left(\frac{v}{\mathrm{c}}\right)^2}},$$

$$j_{A,k} \to j_{A,k}^{'} = \frac{j_{A,k} - v\rho_A}{\sqrt{1 - \left(\frac{v}{\mathrm{c}}\right)^2}},$$

$$j_{A,s} \to j_{A,s}^{'} = j_{A,s} \text{ for } s \neq k.$$

* Correspondence: Gunn Quznetsov, Chelyabinsk State University, Chelyabinsk, Russia. E-mail: gunn@mail.ru

[1] Denote: $\underline{x} := \langle x_0, \mathbf{x} \rangle := \langle x_0, x_1, x_2, x_3 \rangle$; $t := (1/\mathrm{c})x_0$; c = 299792458.

for $s \in \{1, 2, 3\}$ and $k \in \{1, 2, 3\}$ under the Lorentz transformations:

$$t \to t' = \frac{t - \frac{v}{c^2} x_k}{\sqrt{1 - \left(\frac{v}{c}\right)^2}},$$

$$x_k \to x_k' = \frac{x_k - vt}{\sqrt{1 - \left(\frac{v}{c}\right)^2}},$$

$$x_s \to x_s' = x_s \text{ for } s \neq k.$$

In that case $\mathbf{u}_A\langle u_{A;1}, u_{A;2}, u_{A;3}\rangle$ is called *a vector of local velocity* of an event A *probability propagation* and $\mathbf{j}_A\langle j_{A;1}, j_{A;2}, j_{A;3}\rangle$ is called *a current vector* of an event A probability.

Let us consider the following set of four real equations with eight real unknowns: b^2 with $b > 0$, $\alpha, \beta, \chi, \theta, \gamma, \upsilon, \lambda$:

$$\begin{cases} b^2 = \rho_A, \\ b^2((\cos\alpha)^2 \sin 2\beta \cos(\theta - \gamma) - (\sin\alpha)^2 \sin 2\chi \cos(\upsilon - \lambda)) = -\frac{j_{A,1}}{c}, \\ b^2((\cos\alpha)^2 \sin 2\beta \sin(\theta - \gamma) - (\sin\alpha)^2 \sin 2\chi \sin(\upsilon - \lambda)) = -\frac{j_{A,2}}{c}, \\ b^2((\cos\alpha)^2 \cos 2\beta - (\sin\alpha)^2 \cos 2\chi) = -\frac{j_{A,3}}{c}. \end{cases} \quad (1)$$

This set has solutions for any ρ_A and $j_{A;k}$. For example, one of these solutions can be found in [6].

If

$$\begin{cases} \varphi_1 := be^{i\gamma} \cos\beta \cos\alpha, \\ \varphi_2 := be^{i\theta} \sin\beta \cos\alpha, \\ \varphi_3 := be^{i\lambda} \cos\chi \sin\alpha, \\ \varphi_4 := be^{i\upsilon} \sin\chi \sin\alpha \end{cases} \quad (2)$$

then

$$\begin{cases} \rho_A = \sum_{s=1}^{4} \varphi_s^* \varphi_s & (3) \\ \frac{j_{A,r}}{c} = \sum_{k=1}^{4} \sum_{s=1}^{4} \varphi_s^* \beta_{s,k}^{[r]} \varphi_k & (3a) \end{cases}$$

with $r \in \{1, 2, 3\}$ and with

$$\beta^{[1]} := \begin{bmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 \\ 0 & 0 & -1 & 0 \end{bmatrix}, \beta^{[2]} := \begin{bmatrix} 0 & -i & 0 & 0 \\ i & 0 & 0 & 0 \\ 0 & 0 & 0 & i \\ 0 & 0 & -i & 0 \end{bmatrix}, \beta^{[3]} := \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

These functions φ_s are called functions of event A state.

If $\rho_A(\underline{x}) = 0$ for all $\underline{x}$ such that $|\underline{x}| > (\pi c/h)$ with h:= 6.6260755×10^{-34} then $\varphi_s(x)$ are Planck's functions [4]. And if

$$\varphi := \begin{bmatrix}\varphi_1\\ \varphi_2\\ \varphi_3\\ \varphi_4\end{bmatrix}$$

then there exist matrix $\hat{Q}$ so that

$$\hat{Q} = \begin{bmatrix} \mathrm{i}\vartheta_{1,1} & \mathrm{i}\vartheta_{1,2}-\varpi_{1,2} & \mathrm{i}\vartheta_{1,3}-\varpi_{1,3} & \mathrm{i}\vartheta_{1,4}-\varpi_{1,4}\\ \mathrm{i}\vartheta_{1,2}+\varpi_{1,2} & \mathrm{i}\vartheta_{2,2} & \mathrm{i}\vartheta_{2,3}-\varpi_{2,3} & \mathrm{i}\vartheta_{2,4}-\varpi_{2,4}\\ \mathrm{i}\vartheta_{1,3}+\varpi_{1,3} & \vartheta_{2,3}+\varpi_{2,3} & \mathrm{i}\vartheta_{3,3} & \mathrm{i}\vartheta_{3,4}-\varpi_{3,4}\\ \mathrm{i}\vartheta_{1,4}+\varpi_{1,4} & \mathrm{i}\vartheta_{2,4}+\varpi_{2,4} & \mathrm{i}\vartheta_{3,4}+\varpi_{3,4} & \mathrm{i}\vartheta_{4.4} \end{bmatrix} \tag{4}$$

with real $\vartheta_{s,k}$ and $\varpi_{s,k}$, and φ obeys the following differential equation [4]:

$$\partial_t\varphi = \mathrm{c}\left(\sum_{r=1}^{3}\beta^{[r]}\partial_r + \hat{Q}\right)\varphi. \tag{5}$$

In that case if

$$\hat{H} := \mathrm{i\,c}\left(\sum_{r=1}^{3}\beta^{[r]}\partial_r + \hat{Q}\right)$$

then $\hat{H}$ is called a Hamiltonian of the moving with equation (5).
Operator $\hat{U}(t, t_0)$ with domain and with range of values on the set of state vectors is called *an evolution operator* if each state vector ' fulfills the following condition:

$$\varphi(t) = \hat{U}(t,t_0)\varphi(t_0). \tag{6}$$

Let us denote:

$$\hat{H}_d := \mathrm{i\,c}\left(\sum_{r=1}^{3}\beta^{[r]}\partial_r\right).$$

In that case:

$$\hat{H} = \hat{H}_d + \mathrm{ic}\hat{Q}$$

according to the Hamiltonian definition.

From (5):

$$i\partial_t\varphi = \hat{H}\varphi.$$

Hence,

$$i\partial_t\varphi = \left(\hat{H}_d + \mathrm{ic}\hat{Q}\right)\varphi.$$

This differential equation has the following solution:

$$\varphi(t)=\left(\exp\left(-i\widehat{H}_d(t-t_0)+c\int_{t=t_0}^{t}\widehat{Q}dt\right)\right)\varphi(t_0)\,.$$

Hence, from (6):

$$\widehat{U}(t,t_0)=\exp\left(-i\widehat{H}_d(t-t_0)+c\int_{t=t_0}^{t}\widehat{Q}dt\right).$$

The Fourier series for $\varphi_j(t,x)$ has the following shape [4]:

$$\varphi_j(t_0,\mathbf{x})=\sum_{\mathbf{p}}c_{j,\mathbf{p}}(t_0)\varsigma_{\mathbf{p}}(\mathbf{x})$$

with

$$\varsigma_{\mathbf{p}}(\mathbf{x}):=\begin{cases}\left(\frac{\mathrm{h}}{2\pi\mathrm{c}}\right)^{\frac{3}{2}}e^{-\mathrm{i}\frac{\mathrm{h}}{\mathrm{c}}\mathbf{px}}\ if-\frac{\pi\mathrm{c}}{\mathrm{h}}\leq x_k\leq\frac{\pi\mathrm{c}}{\mathrm{h}}\ for\ k\in\{1,2,3\},\\ 0,\ \ otherwize.\end{cases}$$

Therefore, in accordance with properties of Fourier's transformation:

$$\varphi(t,\mathbf{x})=\int_{-\frac{\pi\mathrm{c}}{\mathrm{h}}}^{\frac{\pi\mathrm{c}}{\mathrm{h}}}\int_{-\frac{\pi\mathrm{c}}{\mathrm{h}}}^{\frac{\pi\mathrm{c}}{\mathrm{h}}}\int_{-\frac{\pi\mathrm{c}}{\mathrm{h}}}^{\frac{\pi\mathrm{c}}{\mathrm{h}}}d\mathbf{x}_0\times\left(\frac{\mathrm{h}}{2\pi\mathrm{c}}\right)^3\sum_{\mathbf{p}}\left(\begin{array}{c}\exp\left(-i\widehat{H}_d(t-t_0)+c\int_{t=t_0}^{t}\widehat{Q}dt\right)\times\\ \times\exp\left(-\mathrm{i}\frac{\mathrm{h}}{\mathrm{c}}\mathbf{p}(\mathbf{x}-\mathbf{x_0})\right)\end{array}\right)\times\varphi(t_0,\mathbf{x_0}).$$

An operator

$$K(t-t_0,\mathbf{x}-\mathbf{x}_0,t,t_0):=\left(\frac{\mathrm{h}}{2\pi\mathrm{c}}\right)^3\sum_{\mathbf{p}}\left(\begin{array}{c}\exp\left(-i\widehat{H}_d(t-t_0)+c\int_{t=t_0}^{t}\widehat{Q}dt\right)\times\\ \times\exp\left(-\mathrm{i}\frac{\mathrm{h}}{\mathrm{c}}\mathbf{p}(\mathbf{x}-\mathbf{x_0})\right)\end{array}\right)$$

is called *a propagator* of the *A* probability.

Hence,

$$\varphi(t,\mathbf{x})=\int_{-\frac{\pi\mathrm{c}}{\mathrm{h}}}^{\frac{\pi\mathrm{c}}{\mathrm{h}}}\int_{-\frac{\pi\mathrm{c}}{\mathrm{h}}}^{\frac{\pi\mathrm{c}}{\mathrm{h}}}\int_{-\frac{\pi\mathrm{c}}{\mathrm{h}}}^{\frac{\pi\mathrm{c}}{\mathrm{h}}}d\mathbf{x}_0\times K(t-t_0,\mathbf{x}-\mathbf{x}_0,t,t_0)\times\varphi(t_0,\mathbf{x_0})\,.\qquad(7)$$

But this propagator acts for the probability, but not for particles.

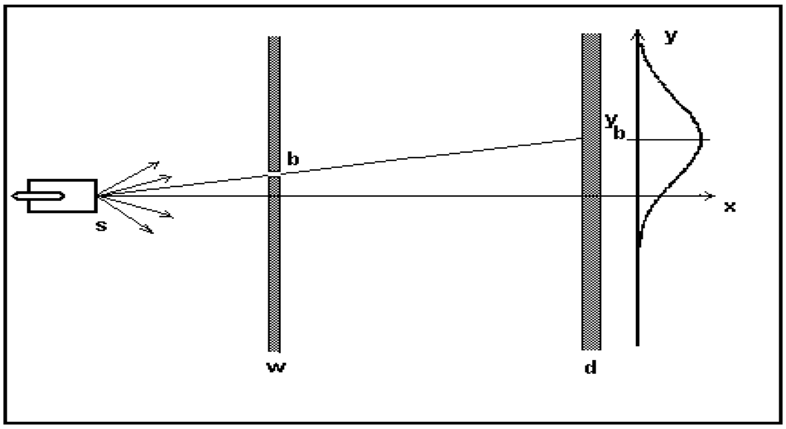

Fig.1

A propagator has the following property:

$$K(t-t_0,\mathbf{x}-\mathbf{x}_0,t,t_0)=$$
$$=\int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}}\int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}}\int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} d\mathbf{x}_1\times K(t-t_1,\mathbf{x}-\mathbf{x}_1,t,t_1)\times K(t_1-t_0,\mathbf{x}_1-\mathbf{x}_0,t_1,t_0).$$

Double-Slit experiment

In vacuum (Fig.1, Fig.2, Fig.3): Here transmitter *s* of electrons, wall *w* and electron detecting black screen *d* are placed [7]. Electrons are emitted one by one from the source *s*. When an electron hits against screen *d* a bright spot arises in the place of clash on *d*.

1. Let slit *a* be opened in wall *w* (Fig.1). An electron flies out of *s*, passes by *a*, and is detected by *d*.

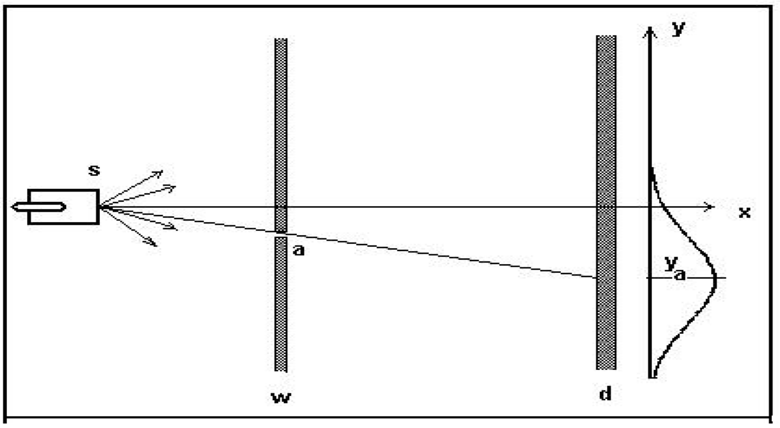

Fig.2

If such operation will be reiterated *N* times then *N* bright spots will arise on *d* against slit a in the

vicinity of point y_a.
2. Let slit *b* be opened in wall *w* (Fig.2). An electron flies out of *s*, passes by *b*, and is detected by *d*.

If such operation will be reiterated *N* times then *N* bright spots will arise on *d* against slit *b* in the vicinity of point y_b.

3. Let both slits be opened. In this case the result like Fig.3 is expected, isn't it? But no. We get the same result as on[2] Fig.4 [8].

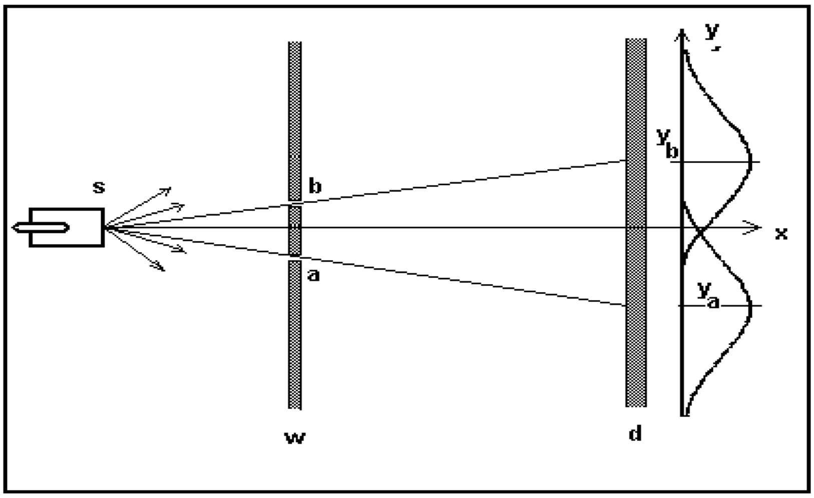

Fig.3

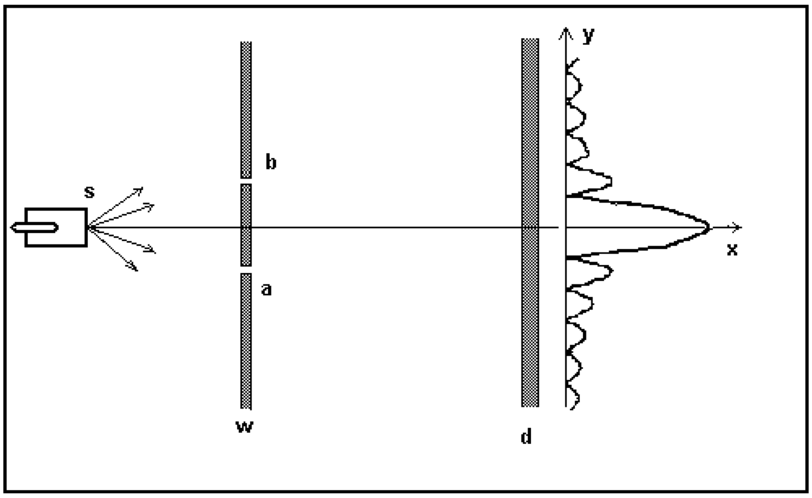

Fig.4

For instance, such experiment was realized at Hitachi by A. Tonomura, J. Endo, T. Matsuda, T. Kawasaki and H. Ezawa in 1989. It was presumed that interference fringes are produced only when two electrons pass through both slits simultaneously. If there were two electrons from the

2 Single-electron events build up over a 20 minute exposure to form an interference pattern in this double-slit experiment by Akira Tonomura and co-workers. (a) 8 electrons; (b) 270 electrons; (c) 2000 electrons; (d) 60,000. A video of this experiment will soon be available on the web (www.hqrd.hitachi.co.jp/em/doubleslit.html).

source s at the same time, such interference might happen. But this cannot occur, because here is no more than one electron from this source at one time. Please keep watching the experiment a little longer. When a large number of electrons is accumulated, something like regular fringes begin to appear in the perpendicular direction as Fig.5(c) shows. Clear interference fringes can be seen in the last scene of the experiment after 20 minutes (Fig.5(d)). It should also be noted that the fringes are made up of bright spots, each of which records the detection of an electron. We have reached a mysterious conclusion. Although electrons were sent one by one, interference fringes could be observed. These interference fringes are formed only when electron waves pass through on both slits at the same time but nothing other than this. Whenever electrons are observed, they are always detected as individual particles. When accumulated, however, interference fringes are formed. Please recall that at any one instant here was at most one electron from *s*. We have reached a conclusion which is far from what our common sense tells us.

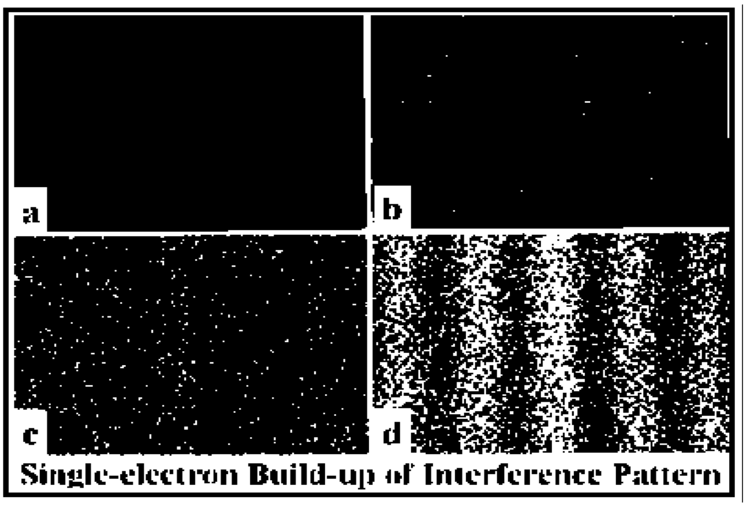

Fig.5

4. But nevertheless, across which slit the electron has slipped?

Let (Fig.6) two detectors d_a and d_b and a photon source *sf* be added to devices of Fig.4.

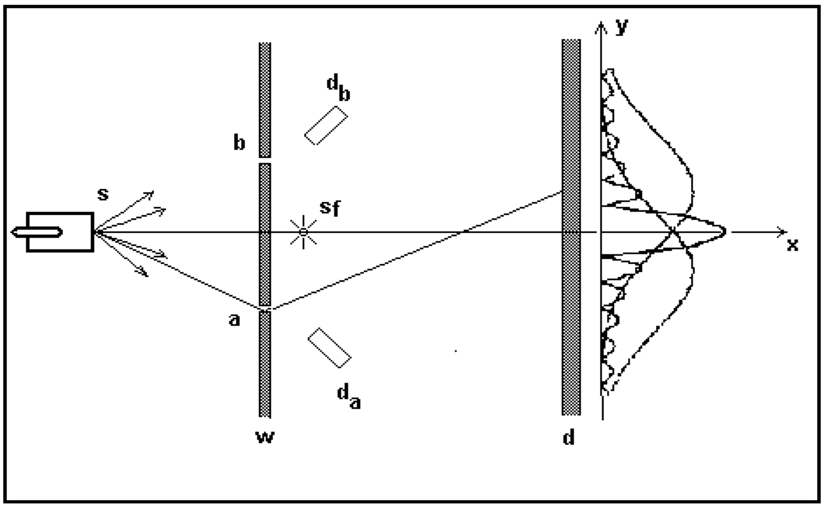

Fig.6

An electron slipped across slit a is lighten by source sf and detector d_a snaps into action. And an electron slipped across slit b is lighten by source sf and detector d_b snaps into action.

If photon source sf lights all N electrons slipped across slits we received the picture of Fig. 3.

If source sf is faint then only a little part of N electrons slipped across slits is noticed by detectors d_a and d_b. In that case electrons noticed by detectors d_a or d_b make picture presented on Fig.3 and all unnoticed electrons make picture presented on Fig.4. In result the Fig.6 is recieved.

Event-Probability Interpretation

Let us try to interpret these experiments by events and probabilities.

Let source s coordinates be (x_0, y_0), the slit a coordinates be (x_a, y_a), the slit b coordinates be (x_b, y_b). Here $x_a = x_b$ and the wall w equation is $x = x_a$.

Let screen d equation be $x = x_d$.

Denote:
an event, expressed by sentence: «electron is detected in point (t, x, y)»: $C(t, x, y)$,
an event, expressed by sentence «slit a is open»: A,
and an event, expressed by sentence «slit b is open»: B.

Let t_0 be a moment of time when an electron is emitted from source s.

Since s is a pointlike source a state vector φ_C in instant t_0 has the following form:

$$\varphi_C(t,x,y)|_{t=t_0} = \varphi_C(t_0,x,y)\delta(x-x_0)\delta(y-y_0). \tag{8}$$

Let t_w be a moment of time such that if event $C(t, x, y)$ occurs in that instant then $C(t, x, y)$ occurs on wall w.

Let t_d be a moment of time of an electron detecting screen d.

1. Let slit a be opened in wall w (Fig.1).

In that case the $C(t, x, y)$ probabilities propagator $K_{CA}(t - t_0, x - x_s, y - y_s)$ in instant t_w should be of the following shape:

$$K_{CA}(t-t_0,x-x_s,y-y_s)|_{t=t_w} = K_{CA}(t_w-t_0,x-x_s,y-y_s)\delta(x-x_a)\delta(y-y_a).$$

According to the propagator property:

$$K(t-t_0,x-x_s,y-y_s) =$$
$$= \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx_1 \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy_1 \times K(t-t_1,x-x_1,y-y_1) \times\times K(t_1-t_0,x_1-x_s,y_1-y_s).$$

Hence,

$$K_{CA}(t_d - t_0, x_d - x_s, y_d - y_s) = \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy \times K_{CA}(t_d - t_w, x_d - x, y_d - y) \times \times K_{CA}(t_w - t_0, x - x_s, y - y_s)\delta(x - x_a)\delta(y - y_a).$$

Therefore, according to properties of δ-function:

$$\boldsymbol{K_{CA}(t_d - t_0, x_d - x_s, y_d - y_s) = K_{CA}(t_d - t_w, x_d - x_a, y_d - y_a)K_{CA}(t_w - t_0, x_a - x_s, y_a - y_s)}.$$

The state vector for the event $C(t, x, y)$ in condition A probability has the following form (7):

$$\varphi_{CA}(t_d, x_d, y_d) = \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx_s \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy_s \times K_{CA}(t_d - t_0, x_d - x_s, y_d - y_s)\varphi_C(t_0, x_s, y_s).$$

Hence, from (8):

$$\varphi_{CA}(t_d, x_d, y_d) = \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx_s \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy_s \times K_{CA}(t_d - t_0, x_d - x_s, y_d - y_s)\varphi_C(t_0, x_s, y_s) \times \times \delta(x_s - x_0)\delta(y_s - y_0).$$

That is:

$$\varphi_{CA}(t_d, x_d, y_d) = \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx_s \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy_s \times K_{CA}(t_d - t_w, x_d - x_a, y_d - y_a) \times \times K_{CA}(t_w - t_0, x_a - x_s, y_a - y_s)\varphi_C(t_0, x_s, y_s) \times \times \delta(x_s - x_0)\delta(y_s - y_0).$$

Hence, according to properties of δ-function:

$$\varphi_{CA}(t_d, x_d, y_d) = K_{CA}(t_d - t_w, x_d - x_a, y_d - y_a) \times \times K_{CA}(t_w - t_0, x_a - x_0, y_a - y_0)\varphi_C(t_0, x_0, y_0).$$

In accordance with (3):

$$\rho_{CA}(t_d, x_d, y_d) = \varphi_{CA}^{\dagger}(t_d, x_d, y_d)\varphi_{CA}(t_d, x_d, y_d).$$

Therefore, a probability to detect the electron in vicinity $\Delta x \Delta y$ of point $<x_d, y_d>$ in instant t in condition A equals to the following:

$$\mathrm{P}_a(t_d, x_d, y_d) := \mathrm{P}(C(t_d, \Delta x \Delta y)/A) = \rho_{CA}(t_d, x_d, y_d)\Delta x \Delta y.$$

2. Let slit b be opened in wall w (Fig. 2).

In that case the $C(t\ x,y)$ probabilities propagator $K_{CB}(t - t_0, x - x_s, y - y_s)$ in instant t_w should be of the following shape:

$$K_{CB}(t - t_0, x - x_s, y - y_s)|_{t=t_w} = K_{CB}(t_w - t_0, x - x_s, y - y_s)\delta(x - x_b)\delta(y - y_b).$$

Hence, according to the propagator property:

$$K_{CB}(t_d - t_0, x_d - x_s, y_d - y_s) =$$
$$= \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy \times K_{CB}(t_d - t_w, x_d - x, y_d - y) K_{CB}(t_w - t_0, x - x_s, y - y_s) \times$$
$$\times \delta(x - x_b)\delta(y - y_b).$$

Therefore, according to properties of δ-function:

$$K_{CB}(t_d - t_0, x_d - x_s, y_d - y_s)=$$

$$= K_{CB}(t_d - t_w, x_d - x_b, y_d - y_b) K_{CB}(t_w - t_0, x_b - x_s, y_b - y_s).$$

The state vector for the event $C(t,x,y)$ in condition B probability has the following form (7):

$$\varphi_{CB}(t_d, x_d, y_d) = \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx_s \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy_s \times K_{CB}(t_d - t_0, x_d - x_s, y_d - y_s)\varphi_C(t_0, x_s, y_s).$$

Hence, from (8):

$$\varphi_{CB}(t_d, x_d, y_d) =$$
$$= \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx_s \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy_s \times K_{CB}(t_d - t_0, x_d - x_s, y_d - y_s)\varphi_C(t_0, x_s, y_s) \times$$
$$\times \delta(x_s - x_0)\delta(y_s - y_0).$$

That is:

$$\varphi_{CB}(t_d, x_d, y_d) =$$
$$= \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx_s \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy_s \times K_{CB}(t_d - t_w, x_d - x_b, y_d - y_b) \times$$
$$\times K_{CB}(t_w - t_0, x_b - x_s, y_b - y_s)\varphi_C(t_0, x_s, y_s) \times$$

$$\times\, \delta(x_s - x_0)\delta(y_s - y_0).$$

Hence, according to properties of δ-function:

$$\varphi_{CB}(t_d, x_d, y_d) =$$
$$= K_{CB}(t_d - t_w, x_d - x_b, y_d - y_b) \times$$
$$\times\, K_{CB}(t_w - t_0, x_b - x_0, y_b - y_0)\varphi_C(t_0, x_0, y_0).$$

In accordance with (3):

$$\rho_{CB}(t_d, x_d, y_d) = \varphi^{\dagger}_{CA}(t_d, x_d, y_d)\varphi_{CA}(t_d, x_d, y_d).$$

Therefore, a probability to detect the electron in vicinity $\Delta x \Delta y$ of point $<x_d, y_d>$ in instant t in condition B equals to the following:

$$\mathrm{P}_b(t_d, x_d, y_d) := \mathrm{P}(C(t_d, \Delta x \Delta y)/B) = \rho_{CB}(t_d, x_d, y_d)\Delta x \Delta y.$$

3. Let both slits and a and b are opened (Fig. 4).

In that case the $C(t,x,y)$ probabilities propagator $K_{CAB}(t - t_0, x - x_s, y - y_s)$ in instant t_w should be of the following shape:

$$K_{CAB}(t - t_0, x - x_s, y - y_s)|_{t=t_w} =$$
$$= K_{CAB}(t_w - t_0, x - x_s, y - y_s)\big(\delta(x - x_a)\delta(y - y_a) + \delta(x - x_b)\delta(y - y_b)\big).$$

Hence, according to the propagator property:

$$K_{CAB}(t_d - t_0, x_d - x_s, y_d - y_s) =$$
$$= \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy \times\times K_{CAB}(t_d - t_w, x_d - x, y_d - y)K_{CAB}(t_w - t_0, x - x_s, y - y_s)$$
$$\times\times \big(\delta(x - x_a)\delta(y - y_a) + \delta(x - x_b)\delta(y - y_b)\big).$$

Hence,

$$K_{CAB}(t_d - t_0, x_d - x_s, y_d - y_s) =$$

$$= \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy \times K_{CAB}(t_d - t_w, x_d - x, y_d - y)K_{CAB}(t_w - t_0, x - x_s, y - -y_s)\big(\delta(x - x_a)\delta(y - y_a)\big) +$$

$$+ \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy \times K_{CAB}(t_d - t_w, x_d - x, y_d - y)K_{CAB}(t_w - t_0, x - x_s, y - -y_s)\big(\delta(x - x_b)\delta(y - y_b)\big).$$

Hence, according to properties of δ-function:

$$K_{CAB}(t_d - t_0, x_d - x_s, y_d - y_s)=$$

$$= K_{CAB}(t_d - t_w, x_d - x_a, y_d - y_a)K_{CAB}(t_w - t_0, x_a - x_s, y_a - y_s)+$$

$$+K_{CAB}(t_d - t_w, x_d - x_b, y_d - y_b)K_{CAB}(t_w - t_0, x_b - x_s, y_b - y_s).$$

The state vector for the event *C*(*t*,*x*,*y*) in condition *A* and *B* probability has the following form~(7):

$$\varphi_{CAB}(t_d, x_d, y_d) = \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx_s \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy_s \times K_{CAB}(t_d - t_0, x_d - x_s, y_d - y_s)\varphi_C(t_0, x_s, y_s).$$

Hence, from (8):

$$\varphi_{CB}(t_d, x_d, y_d) =$$

$$= \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx_s \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy_s \times K_{CAB}(t_d - t_0, x_d - x_s, y_d - y_s)\varphi_C(t_0, x_s, y_s) \times$$

$$\times \delta(x_s - x_0)\delta(y_s - y_0).$$

That is:

$$\varphi_{CAB}(t_d, x_d, y_d) = \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dx_s \int_{-\frac{\pi c}{h}}^{\frac{\pi c}{h}} dy_s \times \big(K_{CAB}(t_d - t_w, x_d - x_a, y_d - y_a)K_{CAB}(t_w - -t_0, x_a - x_s, y_a - y_s) + K_{CAB}(t_d - t_w, x_d - x_b, y_d - y_b)K_{CAB}(t_w - t_0, x_b - -x_s, y_b - y_s)\big)\varphi_C(t_0, x_s, y_s) \times \delta(x_s - x_0)\delta(y_s - y_0).$$

Hence, according to properties of δ-function:

$$\varphi_{CAB}(t_d, x_d, y_d) = \big(K_{CAB}(t_d - t_w, x_d - x_a, y_d - y_a)K_{CAB}(t_w - t_0, x_a - x_s, y_a - y_s) + +K_{CAB}(t_d - t_w, x_d - x_b, y_d - y_b)K_{CAB}(t_w - t_0, x_b - x_s, y_b - y_s)\big)\varphi_C(t_0, x_0, y_0).$$

That is:

$$\varphi_{CAB}(t_d, x_d, y_d) =$$

$$= K_{CAB}(t_d - t_w, x_d - x_a, y_d - y_a)K_{CAB}(t_w - t_0, x_a - x_s, y_a - y_s)\varphi_C(t_0, x_0, y_0)$$

$$+ K_{CAB}(t_d - t_w, x_d - x_b, y_d - y_b)K_{CAB}(t_w - t_0, x_b - x_s, y_b - y_s)\varphi_C(t_0, x_0, y_0)$$

Therefore,

$$\varphi_{CAB}(t_d, x_d, y_d) = \varphi_{CA}(t_d, x_d, y_d) + \varphi_{CB}(t_d, x_d, y_d).$$

$$\rho_{CAB}(t_d, x_d, y_d) = \left(\varphi_{CA}(t_d, x_d, y_d) + \varphi_{CB}(t_d, x_d, y_d)\right)^\dagger \left(\varphi_{CA}(t_d, x_d, y_d) + \varphi_{CB}(t_d, x_d, y_d)\right).$$

Since the state vectors are not numbers with the same signs, in general, the modulus of their sum is not equal to the sum of their modules:

$$\left(\varphi_{CA}(t_d,x_d,y_d)+\varphi_{CB}(t_d,x_d,y_d)\right)^{\dagger}\left(\varphi_{CA}(t_d,x_d,y_d)+\varphi_{CB}(t_d,x_d,y_d)\right)\neq$$
$$\neq\left(\varphi_{CA}(t_d,x_d,y_d)\right)^{\dagger}\left(\varphi_{CA}(t_d,x_d,y_d)\right)+\left(\varphi_{CB}(t_d,x_d,y_d)\right)^{\dagger}\left(\varphi_{CB}(t_d,x_d,y_d)\right).$$

then

$$\mathrm{P}_{ab}(t_d,x_d,y_d)\neq\mathrm{P}_a(t_d,x_d,y_d)+\mathrm{P}_b(t_d,x_d,y_d).$$

Hence, we have the Fig.4 picture instead of the Fig.3 picture.

4. Let us consider devices on Fig. 6.

Denote:
event expressed by sentence "detector da snaps into action" as D_a
event expressed by sentence "detector db snaps into action" as D_b.
Since event $C(t,x,y)$ is a pointlike event then events D_a and D_b are exclusive events.

According to the property of operations on events:

$$(D_a+D_b)+\overline{(D_a+D_b)}=\mathrm{T}$$

where T is the sure event, and

$$\overline{(\mathrm{D_a}+\mathrm{D_b})}=\overline{D}_a\overline{D}_b.$$

Hence,
$$\mathrm{D_a}+\mathrm{D_b}+\overline{D}_a\overline{D}_b=\mathrm{T}.$$

Hence,
$$C=CT=C\left(D_a+D_b+\overline{D}_a\overline{D}_b\right).$$

Hence,
$$C=CD_a+CD_b+C\overline{D}_a\overline{D}_b.$$

Therefore, according to the probabilities addition formula for exclusive events:

$$\mathrm{P}\left(C(t_d)\right)=\mathrm{P}(C(t_d)D_a)+\mathrm{P}(C(t_d)\mathrm{D_b})+\mathrm{P}\left(C(t_d)\overline{D}_a\overline{D}_b\right).$$

But:

$$\mathrm{P}(C(t_d)D_a) = \mathrm{P}_a(t_d),$$
$$\mathrm{P}(C(t_d)D_b) = \mathrm{P}_b(t_d),$$
$$\mathrm{P}\left(C(t_d)\overline{D}_a\overline{D}_b\right) = \mathrm{P}_{ab}(t_d).$$

and we receive the Fig. 6 picture.

Thus, here are no paradoxes for the event-probability interpretation of these experiments. We should depart from notion of a continuously existing electron and consider an elementary particle an ensemble of events connected by probability. It’s like the fact that physical particle exists only at the instant when it is involved in some event. A particle doesn’t exist in any other time, but there’s a probability that something will happen to it. Thus, if nothing happens with the particle between the event of creating it and the event of detecting it the behavior of the particle is the behavior of probability between the point of creating and the point of detecting it with the presence of interference.

But what is with Wilson cloud chamber where the particle has a clear trajectory and no interference?

In that case these trajectories are not totally continuous lines. Every point of ionization has neighboring point of ionization, and there are no events between these points.

Consequently, physical particle is moving because corresponding probability propagates in the space between points of ionization. Consequently, particle is an ensemble of events, connected by probability. And charges, masses, moments, etc. represent statistical parameters of these probability waves, propagated in the space-time. It explains all paradoxes of quantum physics. Schrodinger’s cat lives easy without any superposition of states until the micro event awaited by all occures. And the wave function disappears without any collapse in the moment when an event probability disappears after the event occurs.

Hence, entanglement concerns not particles but probabilities. That is when event of the measuring of spin of Alice’s electron occurs then probability for these entangled electrons is changed instantly on whole space. Therefore, nonlocality acts for probabilities, not for particles. But probabilities can not transmit any information

Conclusion

The Quantum Theory equations describe the behaviour of probabilities of pointlike events.

Double-Slit experiment demonstrates that an elementary particle is an ensemble of such events connected by these probabilities.

Quantum Theory is one of the possible ways of processing of probabilistic information**.**

References

[1] A. Einstein, B. Podolsky, and N. Rosen, Phys. Rev. 47, 777 - 780 (1935)
[2] For instance, GianCarlo Ghirardi, preprint arXiv:0904.0958; F G Scholtz, L Gouba, A Hafver, C M Rohwer, J.Phys.A 42:175303,(2009); Virendra Singh, preprint arXiv:0805.1779; Elio Conte, Proceedings Fundamental problems of Sciences,271-304,S.Petersburg (2002)

[3] Anthony Sudbery, Quantum mechanics and the particles of nature, Cambridge University Press (1986)
[4] G. A. Quznetsov, Progress in Physics, 2009, v.2, 96-106;
http://www.ptep-online.com/index files/2009/PP-17-16.PDF
[5] H. Bergson, Creative Evolution. Greenwood press, Wesport, Conn., (1975).
A. N. Whitehead, Process and Reality. Ed. D. R.Griffin and D.W.Sherburne.
The Free Press, N.Y. (1978). M. Capek, The Philosophical Impact oj Contemporary Physics. D. Van Nostrand, Princeton, N.J. (1961). M. Capek. Particles or events. in Physical Sciences and History of Physics. Ed. R. S. Cohen and M. W. Wartorsky. Reidel, Boston, Mass. (1984), p.1. E. C. Whipple jr. Nuovo Cimento A, 11, 92 (1986). J. Jeans, The New Background of Science. Macmillan, N. Y. (1933).
[6] G. Quznetsov, Probabilistic Treatment of Gauge Theories, in series ”Contemporary Fundamental Physics”,
ed. V. Dvoeglazov, Nova Sci. Publ., NY, (2007), pp.40-41
[7] Feynman, R. P., The Theory of Fundamentaln Processes, W. A. Benjamin, INC., NY, (1961), Feynman, R. P., Leighton, R. B., Sands, M., The Feynman Lectures on Physics, vol.3, ch.37 (Quantum behaviour) Addison-Wesley Publishing Company, INC., (1963)
[8] Tonomura, A., Endo, J., Matsuda, T., Kawasaki, T. and Ezawa, H. Demonstration of single-electron buildup of an interference pattern, Am. J. Phys. (1989), 57, 117-120
Double-slit experiment,
http://www.hqrd.hitachi.co.jp/em/doubleslit.cfm Hitachi
http://www.hitachi.com/rd/research/em/doubleslit.html