Locality in EPR Experiments

Hans Joachim Dudek, D-53773 Hennef-Rott, Auf dem Komp 19,
e-mail: hjd-djh@t-online.de, tel.: 01638342740

Key words: Correlation structure of Maxwell fields, Maxwell vacuum, propagation of light in vacuum, entanglement, EPR experiment

Abstract: An information channel between entangled photons of light in EPR experiments is constructed on Fourier space. The information channel is formed by the structure of the vacuum, mediates the information transport outside the conditions of the special relativity theory (SRT) and is causal and local.

1 Introduction

Under application of a representation of Maxwell fields by an energy- momentum tensor and by four dimensional commutators of communication relations of quantum mechanics, described by the components of the vector potential on Fourier space, [1, 2], three dimensional correlation structures with four dimensional fields of photons of light and of photons of static Maxwell fields are formed [3]. The correlation structures are formed from correlations between fields under conditions of the third law of Newton in a rest frame. This means that for each current in the correlation structure another residual current must simultaneously exists with the same amount and the same sign, but with opposite direction.

Photons of light and photons of static Maxwell fields have different correlation structures. The correlation structures of Maxwell photons exists for two spin directions O and X and in two oscillation states. Each of the structures of the photons O and X consists of two parts (1/2) and (0/3), which are related to transversal oscillators ($\mu = 1,\ 2$) and to longitudinal oscillators ($\mu = 0,\ 3$), respectively. For the photons of light and their two spin directions, linear polarized E_1B_2 and E_2B_1 and elliptic polarized photons with wave and particle properties are formed. The photons of static Maxwell fields are forming O-X-photons, in which the spin is reducing to zero. The photons of light and the O-X-photons are forming photons with particle-, with wave- properties and the O-X-photons in addition with magnetic properties. Photons of light and photons of static Maxwell fields are also form photons of vacuum (section 3).The correlation structures of photons of light and of photons of static Maxwell fields are characterized by action, which is described by the four dimensional commutators of communication relations of quantum mechanics. The amount and sign of action determines their oscillation frequency, the sign of the E_i and B_i fields and the sign of charge. Correlation strings in correlation structures between a creator and an annihilator are interpreted as currents. A positive current is flowing from a positive creator to a negative annihilator and a negative current is flowing from a negative creator to a positive annihilator. During change of state all currents flow simultaneously between the creator plane of the structure of the photon, containing all creators to the annihilator plane, containing all annihilators. The flow of currents in the correlation structure of the photons generates action. After the end of an oscillation state all creators are converting into annihilators and all annihilators into creators. This current flow direction is also the propagation direction of the photons in vacuum; the direction of propagation of the photons occurs under conditions of the third law of Newton, [3].

Before starting with a discussion of entanglement, in following first some basic properties of Maxwell photons on correlation space are discussed: the correlation structures of photons of light and of the photons of static Maxwell fields, the three different modes of action, the interaction of the photons of light with the photons of vacuum, and the propagation of photons in vacuum under induction and superposition (overlap).

2 Correlation Structure of Photons of Maxwell Fields

The correlation structures of the photons of light and of the photons of static Maxwell fields will be illustrated at the example of the O-photon of light in oscillation state Z1 and of the O-photon of the O-X-photons of static Maxwell fields of vacuum in state Z1. The elliptic polarized O-photon of light in state Z1 has the following structure:

Elliptic polarised O- photon; positive μ= 0 oscillator in state Z1:

$$
\begin{array}{ccccccccccccc}
 & & & & B_1 & \leftarrow & {}_-A_2 & \rightarrow & E_2 & & & & \\
 & & & & \downarrow & & bo & & \downarrow & & & & \\
 & & & & {}_+\mathbf{A}_2 & & & & {}_+\mathbf{A}_2 & & & & \\
 & & & & \Uparrow & & & & \uparrow & & & & \\
E_2 & \rightarrow & {}_+\mathbf{A}_3 & \leftarrow & \partial A_2 & \Leftarrow & {}_-A_2 & \rightarrow & \partial A_0 & \Leftarrow & {}_-A_0 & \rightarrow & E_1 \\
\uparrow & & & & \uparrow & & OZ1 & & \Downarrow & & & & \downarrow \\
{}_-A_3 & & gl & & {}_-A_3 & & 0/3 & & {}_+\mathbf{A}_0 & & gr & & {}_+\mathbf{A}_0 \\
\downarrow & & & & \Downarrow & & & & \uparrow & & & & \uparrow \\
B_1 & \rightarrow & {}_+\mathbf{A}_3 & \Leftarrow & \partial A_3 & \rightarrow & {}_+\mathbf{A}_1 & \Leftarrow & \partial A_1 & \leftarrow & {}_-A_0 & \rightarrow & B_2 \\
 & & & & \uparrow & & & & \Uparrow & & & & \\
 & & & & {}_-A_1 & & & & {}_-A_1 & & & & \\
 & & & & \downarrow & & bu & & \downarrow & & & & \\
 & & & & B_2 & \rightarrow & {}_+\mathbf{A}_1 & \leftarrow & E_1 & & & &
\end{array}
\tag{1a}
$$

$$
\begin{array}{ccccccccccccc}
 & & & & B_1 & \rightarrow & {}_+A_0 & \leftarrow & E_2 & & & & \\
 & & & & \uparrow & & & & \uparrow & & & & \\
 & & & & {}_-\mathbf{A}_0 & & & & {}_-\mathbf{A}_0 & & & & \\
 & & & & \downarrow & & & & \Downarrow & & & & \\
E_2 & \leftarrow & {}_-\mathbf{A}_2 & \Rightarrow & \partial A_2 & \rightarrow & {}_+A_0 & \Leftarrow & \partial A_0 & \rightarrow & {}_+A_1 & \leftarrow & E_1 \\
\downarrow & & & & \Downarrow & & OZ1 & & \uparrow & & & & \uparrow \\
{}_+A_2 & & & & {}_+A_2 & & 1/2 & & {}_-\mathbf{A}_1 & & & & {}_-\mathbf{A}_1 \\
\uparrow & & & & \uparrow & & & & \Downarrow & & & & \downarrow \\
B_1 & \leftarrow & {}_-\mathbf{A}_2 & \rightarrow & \partial A_3 & \Leftarrow & {}_-\mathbf{A}_3 & \rightarrow & \partial A_1 & \Rightarrow & {}_+A_1 & \leftarrow & B_2 \\
 & & & & \Downarrow & & & & \downarrow & & & & \\
 & & & & {}_+A_3 & & & & {}_+A_3 & & & & \\
 & & & & \uparrow & & & & \uparrow & & & & \\
 & & & & B_2 & \leftarrow & {}_-\mathbf{A}_3 & \rightarrow & E_1 & & & &
\end{array}
\tag{1b}
$$

For the O-photon as a part of O-X-photons of vacuum in state Z1 follows:

$$
\begin{array}{ccccccccccccc}
B_3 & \to & {}_+A_1 & \leftarrow & B_1 & & & & E_2 & \to & {}_+\mathbf{A}_0 & \leftarrow & E_3 \\
\uparrow & & & & \uparrow & & & & \uparrow & & & & \uparrow \\
{}_-\mathbf{A}_1 & & LO & & {}_-\mathbf{A}_1 & & & & {}_-A_0 & & RO & & {}_-A_0 \\
\downarrow & & & & \downarrow & & & & \Downarrow & & & & \downarrow \\
E_2 & \to & {}_+A_1 & \leftarrow & \partial A_2 & \Rightarrow & {}_+A_2 & \leftarrow & \partial A_0 & \Rightarrow & {}_+\mathbf{A}_0 & \leftarrow & E_1 \\
 & & & & \Uparrow & & OZ1 & & \uparrow & & & & \\
 & & & & {}_-\mathbf{A}_2 & & 1/2 & & {}_-\mathbf{A}_1 & & & & \\
 & & & & \downarrow & & +V & & \Downarrow & & & & \\
B_1 & \to & {}_+\mathbf{A}_3 & \Leftarrow & \partial A_3 & \to & {}_+A_1 & \Leftarrow & \partial A_1 & \to & {}_+A_2 & \leftarrow & B_2 \\
\uparrow & & & & \Uparrow & & & & \uparrow & & & & \uparrow \\
{}_-A_3 & & LU & & {}_-A_3 & & & & {}_-\mathbf{A}_2 & & RU & & {}_-\mathbf{A}_2 \\
\downarrow & & & & \downarrow & & & & \downarrow & & & & \downarrow \\
E_3 & \to & {}_+\mathbf{A}_3 & \leftarrow & B_2 & & & & E_1 & \to & {}_+A_2 & \leftarrow & B_3
\end{array}
$$

(2a)

$$
\begin{array}{ccccccccccccc}
B_3 & \to & {}_+\mathbf{A}_2 & \leftarrow & B_1 & & & & E_2 & \to & {}_+A_3 & \leftarrow & E_3 \\
\uparrow & & & & \uparrow & & & & \uparrow & & & & \uparrow \\
{}_-A_2 & & & & {}_-A_2 & & & & {}_-\mathbf{A}_3 & & & & {}_-\mathbf{A}_3 \\
\downarrow & & & & \Downarrow & & & & \downarrow & & & & \downarrow \\
E_2 & \to & {}_+\mathbf{A}_2 & \Leftarrow & \partial A_2 & \to & {}_+A_0 & \Leftarrow & \partial A_0 & \to & {}_+A_3 & \leftarrow & E_1 \\
 & & & & \uparrow & & OZ1 & & \Uparrow & & & & \\
 & & & & {}_-\mathbf{A}_3 & & 0/3 & & {}_-\mathbf{A}_0 & & & & \\
 & & & & \Downarrow & & -V & & \downarrow & & & & \\
B_1 & \to & {}_+A_0 & \leftarrow & \partial A_3 & \Rightarrow & {}_+A_3 & \leftarrow & \partial A_1 & \Rightarrow & {}_+\mathbf{A}_1 & \leftarrow & B_2 \\
\uparrow & & & & \uparrow & & & & \Uparrow & & & & \uparrow \\
{}_-\mathbf{A}_0 & & & & {}_-\mathbf{A}_0 & & & & {}_-A_1 & & & & {}_-A_1 \\
\downarrow & & & & \downarrow & & & & \downarrow & & & & \downarrow \\
E_3 & \to & {}_+A_0 & \leftarrow & B_2 & & & & E_1 & \to & {}_+\mathbf{A}_1 & \leftarrow & B_3
\end{array}
$$

(2b)

The correlation structures of Maxwell photons are three dimensional and are containing all four μ=0,1,2,3 unity oscillators. In the structures (1) and (2) the correlations are depicted by arrows, pointing from creators to annihilators. The double arrows describe the correlations of the fields contained in the commutators of communication relations of quantum mechanics (μ-correlations), the single arrows describe spin correlations. The positive components of the vector potential are described by bolt letters and the others are negative. The X-photon with opposite spin has all correlations inverted, the second oscillation state Z2 in photons of light has in addition all components of the vector potential with opposite sign and in the photons of static Maxwell fields the two states have different correlation directions, the μ = i oscillators have in both oscillation states the same signs and the sign of the $\mu = 0$ oscillator is positive in state Z1 and negative in state Z2. The photons of light contain always two positive and two negative sets of components of the vector potential $\{A_\mu, \mu = 0, 1, 2, 3\}$ and the O-X-photons of static Maxwell fields are formed from five positive and five negative sets. Changing directions of correlations and combining different photons O and X and different signs of components of the vector potential, different photons with wave, with particle and with magnetic properties and the photons of vacuum are obtained, [3].

3 Description of Action on Correlation Space

In the four dimensional correlation structures of photons of light and of photons of static Maxwell fields the commutators of communication relations of quantum mechanics obtain four dimensional structures (1) and (2). As an example, the structures of the $\mu = 0$ unity oscillator are shown in fig.1. The commutators of communication relations are represented in these structures as currents; the currents are those of currents defined in relativistic quantum mechanics, [1]. The two currents in these structures, forming action, are flowing between a positive creator $+_-A_0$ to a negative annihilator $-_+A_0$ and from a negative creator $-_-A_0$ to a positive annihilator $+_+A_0$. If the residual of both currents, related to negative circulation direction (clockwise) is positive (O photon in fig.1A), the currents represent positive action, if it is negative (photon X in fig.1A), negative action, and if the residual current is cancelled, the action is zero and the photon represents the Maxwell vacuum (figures fig.1A and fig1B). The $\mu = 0$ oscillator is considered as the source of action in a four dimensional photon.

Three different modes of the $\mu = 0$ oscillator can be distinguished, fig.1: (A) shows a $\mu = 0$ oscillator, which oscillate between two states: in both states state Z1 and Z2 the action generated by the oscillator is vanishing, because the two contributing photons O and X have the same amount of positive and negative action. In fig.1C a second oscillation state of a $\mu = 0$ oscillator with real action is shown: in state Z1 action of both photons O and X is positive, in state Z2 negative. A third version (B) is obtained, when the two photons O and X in the static O-X-photons have different signs of currents and the same circulation direction. If the amounts of action in fig.1A are in both photons the same, the action is equal zero; we speak about activate virtual action. because this action can be exchanged between the elementary objects in an interaction. A version of action with the same structure (B) as the structure (A) is formed, when the currents in the oscillator have different current signs and the same circulation direction. In such a structure residual currents and the action are zero. We speak about deactivated virtual action; this kind of action is contained in photons of Maxwell vacuum, [4].

The currents in the correlation structure satisfy a conservation law, which describes the conservation of action. In fig.1 the structures (A), (B) and (C) are formed by the photons of static Maxwell fields and the structure (D) by the photons of light. The photons with deactivated action (B) similar to (A) have the same structures, as the active photons of static Maxwell fields. They differ only in the kind of action. The deactivated virtual action of vacuum (B) is not contributing to the change of real or activated virtual action; it is not able to change the properties of elementary objects. The photons of vacuum with deactivated virtual action (B) are the background of physical processes, [8].

4 Interaction Between Photons of Light and Photons of Vacuum

For a simplification of the representation of the properties of the photons in following a description of currents in correlation structures of the photons is used, by assigning the currents with a current sign and with a sign of current circulation direction. The current sign will be deposited in a first place in brackets and the sign of the circulation direction of current at the second place in brackets. A negative circulation direction of currents is defined clockwise in the circulating paths of the correlation structure. If for example the positive current is flowing in negative circulation direction in the path of the correlation structure, this is described by (+−). In each part (1/2) and (0/3) of the correlation structure of a photon a current can be assigned to the unity oscillators; both parts together are forming the commutators of communication relations. The currents of the two parts $(1/2)/(0/3) = (+-)/(-+)$ or $(-+)/(+-)$ are forming positive action and the currents $(1/2)/(0/3) = (--)/(++)$ or $(++)/(--)$ are forming negative action; other combination of signs result in action equal zero and are characteristic for the currents in Maxwell vacuum with deactivated action. The currents in fig.1A for the O-photon, for example, are described by $(1/2)/(0/3) = (-+)/(+-)$ and for the X-photon $(1/2)/(0/3) = (+-)/(-+)$. This corresponds to the currents:

$$\begin{aligned}&\text{O: } (1/2)/(0/3)\text{: } +_+A_0 \Leftarrow \partial A_0 \Leftarrow -_-A_0 \text{ and } +_-A_0 \Rightarrow \partial A_0 \Rightarrow -_+A_0\\ &\text{X: } (1/2)/(0/3)\text{: } +_-A_0 \Rightarrow \partial A_0 \Rightarrow -_+A_0 \text{ and } +_+A_0 \Leftarrow \partial A_0 \Leftarrow -_-A_0\end{aligned} \qquad (3)$$

where ∂A_0 describes the cub in fig.1, formed from twelve correlations between the derivatives of the components of the vector potential. The cubes are a result of transformation of the trace of the energy momentum tensor of Maxwell fields on Fourier space. The arrows in (3) directed to the left describe the positive circu-

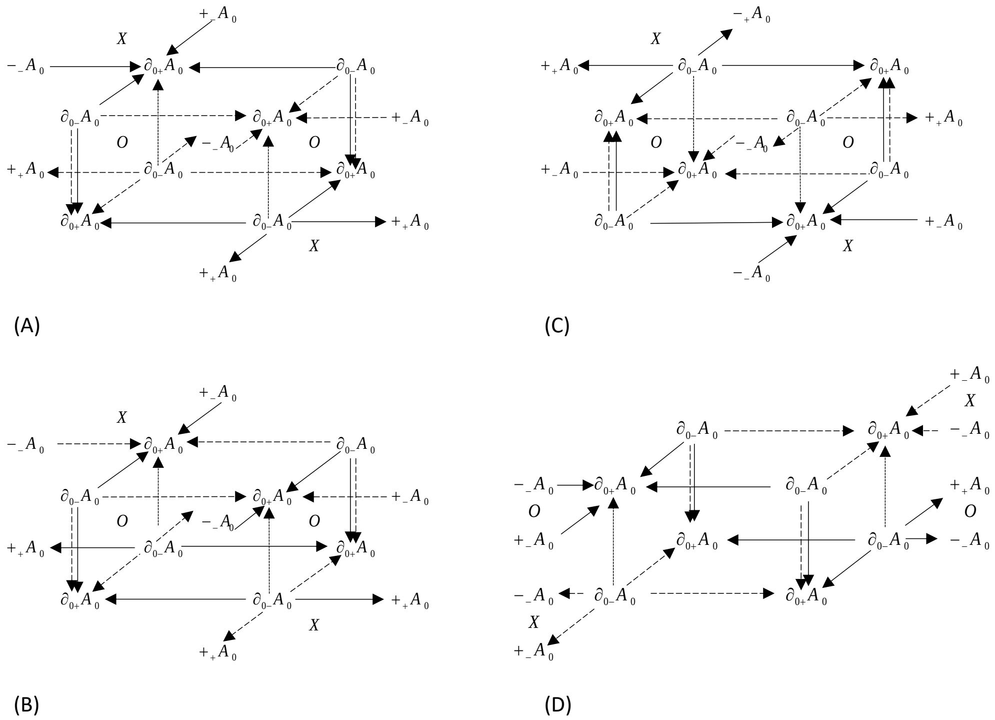

Figure 1: The $\mu = 0$ unity oscillators (A) with a positive action in state Z1 in photons O and negative action in photon X of the static O-X-photon, (B) the same oscillation state of the photons of vacuum of static Maxwell fields with deactivated virtual action, (C) the second oscillation state Z2 of the $\mu = 0$ unity oscillator with negative action in the O-X-photon of static Maxwell fields and (D) the $\mu = 0$ oscillator of the superimposed photons O and X of light in state Z1 with positive action. Arrows describe correlations.

lation direction and arrows directed to the right the negative circulation direction. The currents in the O- and X-photons form after transformation into space time together with the $\mu = \mathrm{i}$ currents the covariant four dimensional commutators of communication relations of quantum mechanics. The two currents in the $\mu = 0$ oscillator of fig.1(A) of the O or X-photon generate the commutator O: $[A_0, \partial_0 A_0]$ and X: $[\partial_0 A_0, A_0]$ and symbolize positive and negative action. (Remark: In quantum mechanics the commutators depend on time. The dependence on time in the presented formalism is always realized by the four dimensional structure of the Maxwell photons.)

The photons of light with the spin O and X can be represented by the following currents in the two longitudinal oscillators: $\mu = 0$ and $\mu = 3$ (the transversal oscillators: $\mu = 1$ and $\mu = 2$ form in photons of light deactivated virtual action with currents of different sign and the same circulation direction):

O-photon	X-photon
Oscillation state Z1:	
$\mu = 0\ (+-)/(-+)$	$\mu = 0\ (-+)/(+-)$,
$\mu = 3\ (++)/(--)$	$\mu = 3\ (--)/(++)$
Oscillation state Z2:	
$\mu = 0\ (++)/(--)$	$\mu = 0\ (--)/(++)$,
$\mu = 3\ (+-)/(-+)$	$\mu = 3\ (-+)/(+-)$

There are two kinds of photons of vacuum of static Maxwell fields with wave properties:

$W1_\alpha$=OZ1(+)&XZ1(−) and $W2_\alpha$=OZ2(+)&XZ2(−) and
$W1_\beta$ = OZ1(−)&XZ1(+) and $W2_\beta$ = OZ2(−)&XZ2(+)

In following the β-version will be used (Under conditions of action minimization the β-version is preferred.). The photons $W1_\beta$ and $W2_\beta$ are characterized by the following currents:

State $W1_\beta$ = OZ1(−)&XZ1(+)
OZ1(−): $\mu = 0\ (--)/(+-)$, $\mu = 3\ (--)/(+-)$,
XZ1(+): $\mu = 0\ (++)/(-+)$, $\mu = 3\ (++)/(-+)$,

State $W2_\beta$ = OZ2(−)&XZ2(+)
OZ2(−): $\mu = 0\ (-+)/(++)$, $\mu = 3\ (-+)/(++)$,
XZ2(+): $\mu = 0\ (+-)/(--)$, $\mu = 3\ (+-)/(--)$,

The interaction between the photons of light and the photons of vacuum occurs by superposition of parallel and equal-directed currents separately for the two parts (1/2) and (0/3). (The sign in brackets at the notation of the photons O or X describe the sign of action in $\mu = 3$ oscillators). In following possible interactions of the O- and of the X-photon of light in the two states Z1 and Z2 with the vacuum photons in states W1 and W2 are summarized (Arrows to the right describe the result of interaction.):

O-photon of light, $\mu = 0$
(1/2): Z1: O(+−) + OZ1(−) (−−) → (+−)
(0/3): Z1: O(−+) + OZ2(−) (++) → (−+)
(1/2): Z2: O(++) + OZ2(−) (−+) → (++)
(0/3): Z2: O(−−) + OZ1(−) (+−) → (−−)

X-photon of light, $\mu = 0$
Z1: (1/2): (−+) + W1: XZ1(+): (++) → (−+)
Z1: (0/3): (+−) + W2: XZ2(+): (−−) → (+−)
Z2: (1/2): (−−) + W2: XZ2(+): (+−) → (−−)
Z2: (0/3); (++) + W1: XZ1(+): (−+) → (++)

O-photon of light, $\mu = 3$
Z1: (1/2): (++) + W2:OZ2(−): (−+) → (++)
Z1: (0/3): (−−) + W1:OZ1(−): (+−) → (−−)
Z2: (1/2): (+−) + W1:OZ1(−): (−−) → (+−)
Z2: (0/3): (−+) + W2:OZ2(−): (++) → (−+)

X-photon of light, $\mu = 3$
Z1: (1/2): (−−) + W2:XZ2(+) (+−) → (−−)
Z1: (0/3): (++) + W1:XZ1(+) (−+) → (++)
Z2: (1/2): (−+) + W1:XZ1(+) (++) → (−+)
Z2: (0/3): (+−) + W2:XZ2(+) (−−) → (+−)

It is assumed that the action of the photons of vacuum is essential lower than the action of the photons of light. A superposition of the photons of vacuum will not change the current sign of the photons of light. All currents of the photons of the vacuum are subtracted from the photons of light. The photons of vacuum are completely consumed, when both photons O and X of light are acting together; if only one of the two photons of light is interacting with the vacuum, the other part of the vacuum remains.

As it is shown in fig.1 by a comparison between the photons of activated and of deactivated vacuum (A) and (B), these two photons of vacuum have the same structure and form together the Maxwell vacuum including the gravitation, [4]. The $\mu = 0$ oscillator in fig.1A is generating the action of the gravitons. In gravitation a subtraction of currents of gravitons from photons of light occurs, which is the condition for a red shift of spectral lines in gravitation.

5 Propagation of Photons of Light in Vacuum

The photons of electromagnetic interaction and the photons of light, as represented in this report by their unity oscillators and as shown in fig.1, interact between each other by superposition (overlap), entanglement and induction. Interaction between Maxwell photons occurs always under condition of action minimization (Principle of Hamilton on space time). In superposition photons overlap under interference, in entanglement parallel currents with the same circulation direction of the photons overlap under algebraic addition of currents. The induction occurs under conditions of the third law of Newton: during formation of a current flowing in one direction, a residual current is formed in the structure of the photons, with the same current sign and the same amount, simultaneously flowing in opposite direction.

The propagation of photons of light in vacuum occurs according to induction: during formation of an oscillation state of the photon, at the same time in the direction of propagation a correlation structure of the photon in vacuum is formed (induced). During the following oscillation state the currents, responsible for the formation of action, are flowing into, in front formed, correlation structure of the photon. This propagation occurs with the speed of light, it is connected with the transport of action.

Another transport of information is possible under conditions of induction: If, as described, a photon of vacuum in front of the active photon of light is formed, for this induced photon of vacuum the next one simultaneously, according to third law of Newton is formed, and in front of this new vacuum photon at the same time another vacuum photon is formed, and so on. In this way only the structure of the photon of light is propagating in vacuum; the induced vacuum photons are formed from the action of the vacuum and the currents of the photon of light, while the source of action remain in the photon of light, being generated by the components A_0 of the vector potential. We call the formation of such vacuum photons a wave train, in analogy to the formation of wave trains in coherent electron beams. The wave trains are formed simultaneously with the formation of a state of a photon of light in vacuum. The propagation of structure information in vacuum by a wave train occurs not under conditions of SRT, because no action is transporting. In following the information transport in entanglement will be discussed, which propagate in vacuum also under conditions of the third law of Newton and occurs outside the conditions of the SRT.

The mechanism of propagation of action in vacuum occurs under minimization of action and can be visualized at the example of the $\mu = 0$ oscillator: the vertical correlations in the correlation structure of unity cubes describe the products of derivations of the fields in the dynamic equations and the commutator of communication relations, attached to the $\mu = 0$ oscillator can be interpreted as an exchange of signs by simultaneously flowing currents between a positive $+A_0$ and a negative $-A_0$ component of the vector potential: during a change of state, which is connected with a halve period of oscillation and a propagation of the photon by halve of the wave length, the signs of the two components of the vector potential are exchanged.

6 Representation of Interaction Between Photons of Light and Photons of Vacuum by Correlation Structures

The photons of light move in vacuum by induction that is they generate in addition to the formation of its own state the superimposed state of the vacuum photon and at the same time in direction of movement the following oscillation state, consisting of a superposition of structures of the photon of vacuum and the only structure of photon of light (with action of the vacuum). Two originally in entanglement superimposed photons of light, separate in this way similar according to the propagation direction, by generating their own states in vacuum between each other. This is depicted at the example of the $\mu = 0$ oscillator in fig.2.

Fig.2 contain between the two apart from each other moving photons of light two oscillation states, which were generated simultaneously during the separation of the two entangled photons. Above in fig.2 the photon is shown, which is moving up, and at the bottom of fig.2 the photon, moving down; between them two oscillation states, generated by induction under contribution of the formation of photons of vacuum. For clarity in fig.2 the structures of the overlapping states of the two photons of light and the photons of vacuum are depicted side by side separately: at left in fig.2 the oscillation states of the photon moving up and at right

Table 1: In fig.2 the $\mu = 0$ oscillators have the following properties:

A. Photon of light moving down, W1, Z1:
O-photon $(1/2)/(0/3) = (+-)/(-+)$, X-Photon $(1/2)/(0/3) = (-+)/(+-)$,
B. Vacuum photon: moving up, W2, Z2:
O-photon $(1/2)/(0/3) = (++)/(--)$, X-Photon $(1/2)/(0/3) = (--)/(++)$,

E. Vacuum photon: moving down, W2, Z2:
O-photon $(1/2)/(0/3) = (--)/(++)$, X-Photon $(1/2)/(0/3) = (++)/(--)$,
F. Vacuum photon: moving up, W1, Z1:
O-photon $(1/2)/(0/3) = (-+)/(+-)$, X-Photon $(1/2)/(0/3) = (+-)/(-+)$,

G. Vacuum photon: moving down, W1, Z1:
O-photon $(1/2)/(0/3) = (+-)/(-+)$, X-Photon $(1/2)/(0/3) = (-+)/(+-)$,
H. Vacuum photon: moving up,W2 Z2:
O-photon $(1/2)/(0/3) = (++)/(--)$, X-Photon $(1/2)/(0/3) = (--)/(++)$,

D. Vacuum photon: moving down, W1, Z1:
O-photon $(1/2)/(0/3) = (+-)/(-+)$, X-Photon $(1/2)/(0/3) = (-+)/(+-)$,
C. Vacuum photon: moving up, W2, Z2:
O-photon $(1/2)/(0/3) = (++)/(--)$, X-Photon $(1/2)/(0/3) = (--)/(++)$.

the oscillation states of the photon moving down. The photons move in opposite directions, their generated different oscillation states overlap with the same current directions, but with different propagation directions. For example the state G:W1-Z1(+) is superimposing the state H:W2-Z2(−) and the state E:W2, Z2(−) is superimposing the state F:W1,Z1(+). The signs in brackets describe the signs of action in the photon of vacuum superimposed with the photon of light. The results of interaction shown in fig.2 are summarized in table 1. The structure of the generated states of the photons moving apart from each other overlap in their different oscillation states with different signs of action.

In fig.3 the results of table 1 and of fig.2 are schematically depicted. The method used in the present report for the description of Maxwell photons delivers only the oscillation states, not the behaviour of currents between the states. In fig.3 it is assumed that the currents have a sinus form in between the states. The currents of the photon of light moving down are represented by a continuous line and for the photon moving up by a discontinuous line. In between two oscillation states the currents in the photon form one wave length of the sinus function, the sinus functions of the two photons are separated by a halve of an oscillation period. In this representation it is assumed that the two photons of light contain the same action; in each oscillation period the currents of the two photons annihilate each other. This is not only the case for the two different photons, but also for each single photon, because the two longitudinal oscillators have also a different current sign in each oscillation period, as a comparison between the two parts $\mu = 0$ and $\mu = 3$ in fig.3 shows.

7 Locality in EPR Experiments

From fig.2 the development of the common oscillation system of two photons in an EPR experiment is depicted: Originally the two photons with opposite direction of moving are entangled by a common creator- or annihilator plan. In fig.2 this is the lower plane of structure G-H and the upper plane of E-F with a creator plane, separating two opposite oscillation states. In the common creator plane the two photons have the same correlation directions (current directions) with currents of opposite signs. The currents of both photons are forming a common oscillation system; the currents of both photons overlap in both photons, form a common current in both photons and cannot be distinguished. The currents annihilate each other for equal current amounts; a current reduction minimizes the action and provides the system of both photons with stability. The photons separate from each other by the simultaneous formation of a new oscillation state into their direction of movement.

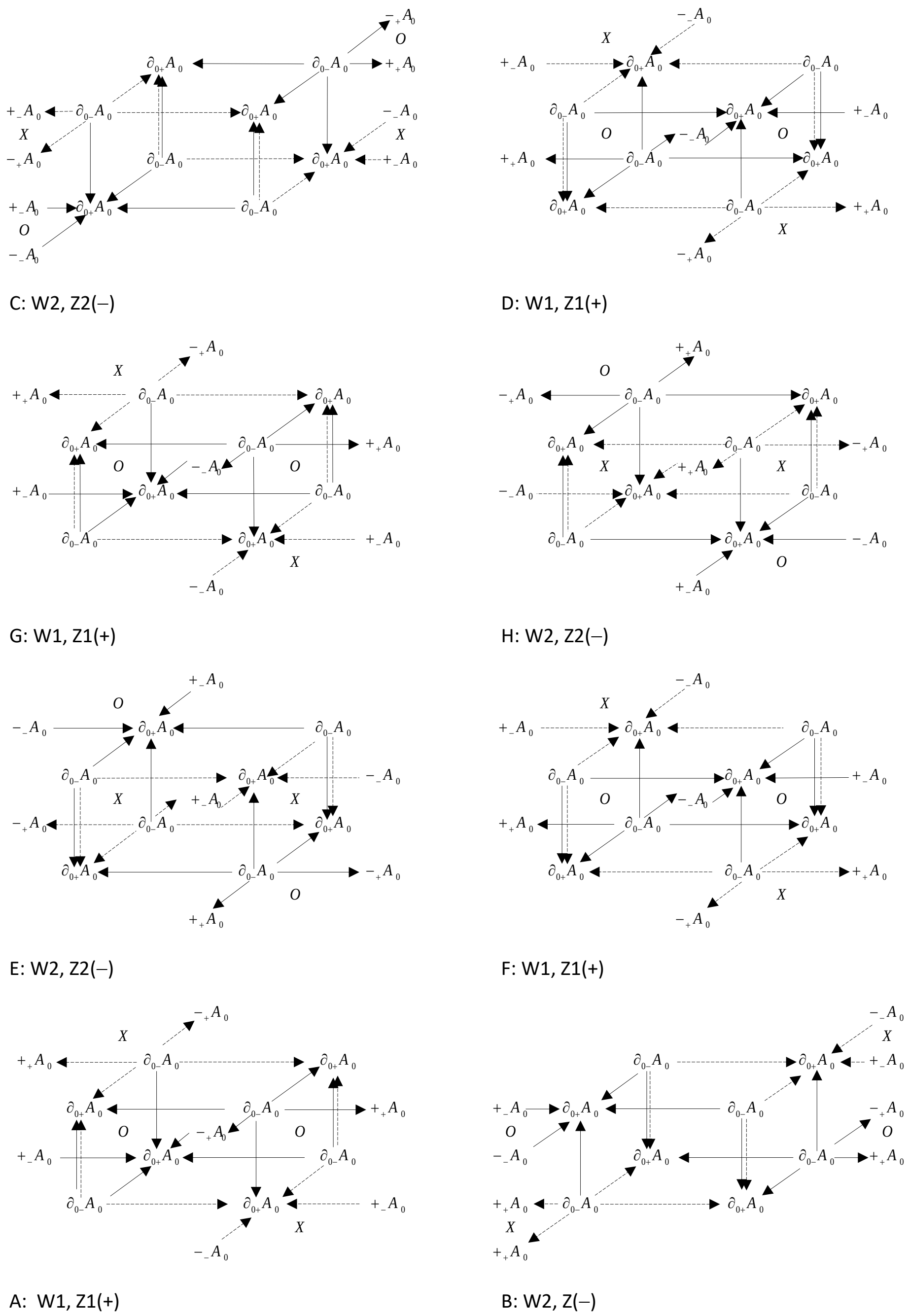

Figure 2: Illustration of the interaction between the O- and X-photons of light with O-X-photons of vacuum in an EPR experiment immediately after separation of the two photons of light at example of the $\mu = 0$ oscillator.

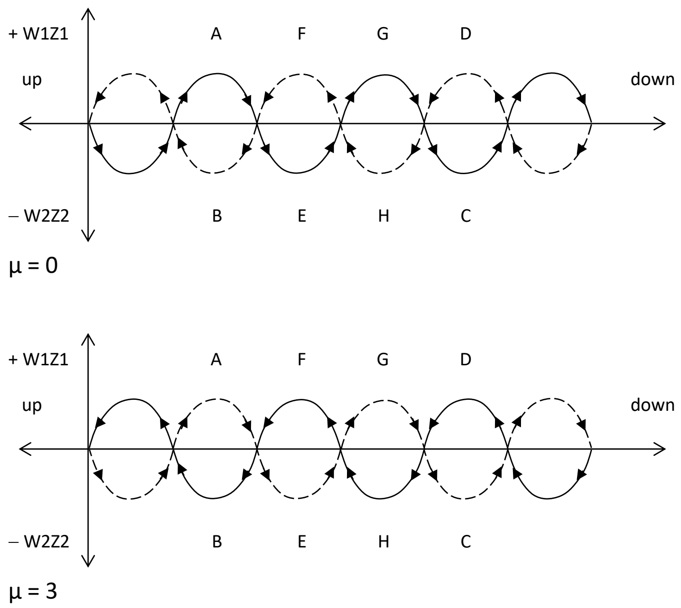

Figure 3: Schematic representation of the oscillation of currents in the oscillators $\mu = 0$ and $\mu = 3$ of correlation structures of photons represented in fig.2.

The propagation of movement occurs by induction: in front of each of the photons, during formation of an oscillation state, in direction of propagation vacuum photons are forming under conditions of the third law of Newton. In the following oscillation state action in form of currents of both photons is flowing into the photons of vacuum, forming a new oscillation state in propagation direction. This situation is shown in fig.2: the two oscillation states C-D and A-B were formed. The original states G-H and E-F remain and perform together with the propagating photons the oscillation, because their currents in their common creator or annihilator plan are further cancelling each other. The next oscillation state will be formed in the same way, as the described previous oscillation.

The entangled photons form together a residual current, which is common to both longitudinal oscillators and to both photons. That means that during entanglement they have the same action that is the same frequency (energy). The situation in fig. 3 with equal currents for both photons is always realized in an entanglement, therefore, independent from the amount of action in both photons. The anti-correlated polarized photons are emitted simultaneously. A simultaneous emission of photons, which can interact under conditions of minimization of action, is a characteristic feature for entanglement. Even when they are emitted simultaneously from different sources, they are able to interact over their vacuum waves and can generate an entanglement. When the entangled photons are separated by cancelling the entanglement, their properties are determined by the components of the vector potential, which form the photons and they restore their own currents, their own action and frequency.

Two entangled photons of light, moving apart in opposite directions, form under interaction with the photons of vacuum a common oscillation system of standing waves, which connect locally both photons of light. The action of the photons is annihilated in each oscillation state and between the oscillation states. The currents of each of the photons are cancelled between the two longitudinal oscillators and the two photons have in each oscillation phase different signs of action. The information of both photons is contained in the whole oscillation system. The currents of the photons of light determine the stability of the oscillating system of standing waves; as higher the action of the photons (higher energy) as higher will be the stability of the oscillating system connecting the two moving apart photons. The oscillation occurs under conditions of the third law of Newton: for each current in one direction there is simultaneously another residual current in opposite direction: all currents in the oscillating system are simultaneously reduced to zero. This means that when the properties of one of the photons are measured, under conditions of the third law of Newton, this property is simultaneously measured at the whole oscillating system. The information channel between the two photons is causal and local and information transfer between the two photons underlays not the conditions of the SRT.

8 Discussion

The presented explanation of the non-locality in EPR experiments relays on the existence of a correlation space which is connected with space time. The results will be discussed relating to the publication in [5, 6], in which an EPR experiment of two anti-correlated polarized photons in a free space with no line of sight between each other is described. The characteristic feature of the entanglement of two photons is from view of the results in the present paper the formation of a common structure with a common current, with a common frequency of oscillation and the only structure which results in a common interaction with the deactivated vacuum. The structures of the photons and the structure of the vacuum exist only on correlation space.

The in line of connection between two moving apart from each other entangled photons in the entanglement can be disturbed. This shows that there is an invisible connection between the entangled photons. This connection is hidden on the correlations space and is a structure formed from photons of vacuum. The detectors proving the simultaneity of anti-correlated photons in the experiment of [5] can be considered to be the receiver of information on space time, while the information transfer between the photons occurs on correlation space. The transfer of information from the correlation space to space time in the detectors occurs by in-elastic interaction, while the propagation of information on correlation space occurs elastically that is without of action change. The event on space-time occurs in time by a change of action; while an elastic submission of information on correlation space occurs nearly time less. The elastic transfer of information is a transfer of structure information without a submission of action and occurs under the conditions of the third law of Newton. This shows the basic difference of properties of the two spaces: change of action is always connected with an event on space time, [7], occurring in space and time. For events occurring only elastically on correlations space there is no space and no time.

In quantum mechanics the elementary objects have no properties defined before they are measured. In the experiment [5, 6] the result of measurement at the detectors arise at the moment of detection. This is also the moment of formation of the anti-correlation of polarization. This explanation supports the concept of non-locality. The concept of vacuum of quantum mechanics cannot be used for the explanation of this non-locality. From view of the presented method of the existence of a correlation space the concept of the vacuum allows a local and causal description of entanglement in EPR experiments. Using the description of the vacuum on correlation space, the explanation of the non-locality and other quantum mechanical phenomena [3], follows from the interaction of the structures of photons of light with the structure of the vacuum by induction, by superposition and by entanglement under conditions of action minimization (Principle of Hamilton).

References

[1] M.E. Peskin, D.V. Schroeder, An Introduction to Quantum Field Theory, Westview Press, 1995

[2] Champeney, D.C.: Fourier Transforms and their Physical Applications, Academic, London, 1973,

[3] H.J. Dudek, Physical Information Theory: An Oscillator Approach to the Elementary Particles, manuscript of a book proposed for publication,

[4] H.J. Dudek, Correlation Structure of vacuum, submission in preparation

[5] M. Aspelmeyer, et.al.: Long-Distance Free-Space Distribution of Quantum Entanglement, Science, vol.301, 1 August 2003, p.621-623

[6] J.G. Rarity: Getting Entangled in Free Space, Science, 1 August 2003, vol. 301, p.604-605

[7] Lee Smolin: Einstein's Unfinished Revolution, The Search for What Lies Beyond the Quantum, Penguin Books, 2020

[8] H.J. Dudek, Principle of Equivalence and Wave Properties formation, submitted to

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.