Correlation Structure of Photons of Light

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Abstract: The correlation structures of Maxwell photons of light are constructed with the aid of two positive and two negative sets of components of the vector potential $\{A_\mu\}$, and with the correlations of the cubes obtained by a Fourier transformation of the trace of the energy momentum tensor of Maxwell fields. The properties of the photons of light are discussed on the basis of interference, induction and entanglement. Using longitudinal activated photons, elliptic and linear in $\mathrm{E}_1/\mathrm{B}_2$ and in $\mathrm{E}_2/\mathrm{B}_1$ polarized photons are constructed with "wave" properties. From the photons with "wave" properties, photons with "particle" properties are derived by a simple exchange of signs of the transversal components of the vector potential. The propagation mechanism of the dynamic photons in vacuum is discussed, and entanglement of elliptic and linear polarized photons is constructed.

1 Introduction

If products of fields of the Lagrange density of a physical object are transformed into the Fourier space, correlations are formed from the products, [1, 2]. The correlations can be put together to a "correlation structure" of the object. The construction of correlation structures is performed under the conditions of the principle of simultaneous contrary oscillation (PSCO), [3]. PSCO demands for an oscillator in a rest frame that for each current flow in one direction, a residual current must exists, which at the same time flow with the same amount and the same sign into the opposite direction. The PSCO is realizing for an oscillator in a rest frame the third law of Newton.

The correlation structure represents the physical object in the same way as the Lagrange density, from which it is derived. We obtained on this way from the trace of the energy- momentum tensor of Maxwell fields sixteen cubes, each consisting of twelve correlations between the partial derivative of the vector potential components, which describe the general classic Maxwell fields (for visualization of the cubes see fig.1). Using μ- correlations obtained on Fourier space from the four dimensional commutators of communication relations (μ- commutators), and spin correlations, the sixteen cubes are connected to form a correlation structure of general quantized Maxwell fields. It is assumed that each photon carry action and this action is described by a four dimensional μ- commutator, which is positive in the form $[A_\mu, \partial_\mu A_\mu]$, μ = 0,1,2,3. From the general correlation structure the static and dynamic vacuum [4], and the static and dynamic photons of activated Maxwell fields [4] are obtained. In the present publication the properties of the activated dynamic photons of light will be discussed, derived from the correlation structure of the dynamic Maxwell vacuum.

2 Formation and Properties of Maxwell Photons of Light on Fourier Space

The correlation structure of photons of light exists in two versions O and X, which are distinguished by their correlation directions. The photons O and X consists of two parts (0/3) and (1/2), compare relations (1); the two parts are forming a unity, which is depicted for a better discussion separately. The photons O and X occur in two oscillation states, which have opposite current directions and opposite signs of components of the vector potential. As will be discussed the two photons O and X can be related to two spin directions of quantum mechanics.

The correlation structure of photons of light are obtained from the correlation structure of the dynamic vacuum [4], by exchanging the direction of the correlations in the paths *bo* and *bu* of the part (1/2) in the O- photon (see relations (1)). The other correlation directions and signs and all subscripts of the components of the vector potential of the vacuum structure remain the same. Each dynamic photon O or X oscillates between two states, by changing the correlation direction and the signs of all components of the vector potential. The relations of the correlations for the O-photon shown in the structure (1) are obtained.

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

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

The ∂A_α describe the unity cubes and the E_i and B_i the cubes of the electric and magnetic Maxwell fields, obtained from the trace of the energy momentum tensor. The double arrows describe the μ- correlations of the μ-commutators, and the single arrows the spin correlations. All subscripts of the components of the vector potential are the same as in the structure of the vacuum. The positive sign of the vector potential components are marked by bold letters, the other vector potential components are negative. Each part (0/3) and (1/2) of the photon consists of the *gl* and *gr* paths and of the *bo* and *bu* closed paths. The paths are defined by the properties of the correlations inside the E- and B- cubes: the paths of the dynamic photons have subscripts of the form $\partial_0 A_j \partial_j A_0$ and $\partial_i A_0 \partial_0 A_i$. The paths interact in the unity cubes ∂A_α. The structure (1) describes the state Z1 of the O- photon, with positive $\mu = 0$ and negative $\mu = 3$ commutators. The state Z2 is formed by exchanging all signs of the vector potential components and all correlation directions (compare structures (2)). The X- photon is obtained by changing in the O-photon the circulation direction of all correlations, without changing the signs of correlations.

In the above correlation structure the correlations of the two longitudinal paths in the parts (0/3) and (1/2), forming a μ-commutator, have an opposite circulation direction and in the transversal paths the same circulation direction. If the μ- correlations of state Z1 are determined, using the negative direction of reading (clockwise), we obtain

O-Z1(0/3):

$+_+A_0 \Leftarrow \partial_{0-}A_0 - \partial_{0+}A_0 \Leftarrow_- A_0 \qquad +_+A_3 \Leftarrow \partial_{3-}A_3 - \partial_{3+}A_3 \Leftarrow_- A_3$

$-_-A_1 \Rightarrow \partial_{1+}A_1 + \partial_{1-}A_1 \Rightarrow_+ A_1 \qquad -_-A_2 \Rightarrow \partial_{2+}A_2 + \partial_{2-}A_2 \Rightarrow_+ A_2$

O-Z1(1/2):

$+_-A_0 \Rightarrow \partial_{0+}A_0 - \partial_{0-}A_0 \Rightarrow_+ A_0 \qquad +_-A_3 \Rightarrow \partial_{3+}A_3 - \partial_{3-}A_3 \Rightarrow_+ A_3$

$+_-A_1 \Rightarrow \partial_{1+}A_1 - \partial_{1-}A_1 \Rightarrow_+ A_1 \qquad +_-A_2 \Rightarrow \partial_{2+}A_2 - \partial_{2-}A_2 \Rightarrow_+ A_2$

The sum of the correlations results in the commutators $[A_0, \partial_0 A_0] - [A_3, \partial_3 A_3]$ (Products between two creators or between two annihilators are not forming correlations, [3]). The addition of the $\mu = 1$ and $\mu = 2$- correlations gives zero. From the vacuum a contra variant state Z1 of a dynamic longitudinal activated photon is obtained. The state Z2 analysed in the same way, results in the commutator $-[A_0, \partial_0 A_0] + [A_3, \partial_3 A_3]$. The O-03 photon oscillates between two contra variant states. Each state consists of two parts: a longitudinal (0/3) and a transversal part (1/2). The paths *gr* and *bu* are formed by components, having the subscripts μ = 0,1,3, and the paths *gl* and *bo* by the components with subscripts μ = 0,2,3. The paths *gr* and *bu* contain the cubes of the fields E_1 and B_2 and the paths *gl* and *bo* the cubes of the fields E_2 and B_1.

If the correlation directions and signs of the μ- correlations in both parts (0/3) and (1/2) of the state Z1 in the *bo* and *bu* paths of the dynamic vacuum are exchanged, all μ- correlations are summed up to the commutator $[A_0, \partial_0 A_0] - [A_1, \partial_1 A_1] - [A_2, \partial_2 A_2] - [A_3, \partial_3 A_3]$. The state Z2 results in a commutator with opposite signs. If the signs and the directions of the correlations in the *gl* and *gr* paths of the part (1/2) of the vacuum are exchanged, one obtains a transversal photon with the commutators $-[A_1, \partial_1 A_1] - [A_2, \partial_2 A_2]$ in state Z1, and with opposite sign in state Z2. Changing in these photons all directions of all correlations, without changing the sign, one creates from the O- photon the X- photon. The O and X photons are those of quantum mechanics with different spin direction, as will be discussed in section 7.

3 Oscillation Mechanism of Photons of Light

To explain the oscillation mechanism of the Maxwell photons, it is proposed to use the image of an oscillating current, flowing between the components of the vector potential of the commutators of communication relations, connected to the unity cubes ∂A_α. The currents in the correlation structures are defined by the sign of the creator $\{_-A_\mu\}$ and the circulation direction. The clockwise circulation direction in the path of the photon is defined as negative. Through unity cubes always two currents are flowing defined by the commutators of communication relations. The currents are flowing from a positive or negative creator to an negative or positive annihilator, respectively. Action is formed by two currents flowing with different current signs and different circulation directions. If the residual current from the two currents related to the negative circulation direction is positive, the commutator formed on space time is positive and defines positive action, if the residual current is negative, a negative commutator results and the action is negative. The different currents in the structure of the photon of light in a rest frame have always the same amount, because the oscillation of all parts of the photon occurs simultaneously by a current flowing from all creators of the creator plane to all annihilators of the annihilator plane of the correlation structure of the photon. If two parallel currents with the same circulation direction overlap, currents with different signs cancel each other. Using this assumptions the properties and the oscillation behaviour of the Maxwell photons can be interpreted.

If in a rest frame two currents of opposite current sign are flowing through the unity cube in the same circulation direction in the path, as it is for the vacuum, they compensating each other in each oscillation state and the residual current is zero. The amount of action in the dynamic photons of light is determined by the oscillation frequency in the $\mu = 0$ unity cube, [3]. In activated paths also the currents in the E- and B- cubes are different from zero. When the paths are active, they consists of two correlation lines with opposite correlation directions and of components of the vector potential, having in each part the same sign; they alternate in signs in following part of the path. The signs are changed with the change of state. In the path *bo* in part (0/3) for example, in the correlation structure (1), the components of the vector potential are A_2, and in the part (1/2) the components are A_0; both forming together with the cubes E_2 the field E_2. In the same way the path *gl* of the part (0/3) with the component A_3 form together with the component A_2 of the part (1/2) the field B_1. Both fields oscillate in sign between the two states Z1 and Z2. In a similar way the path *gr* is activated, forming together with the path *bu* the linear polarized photon E_1/B_2. The cubes E_i and B_i are forming dipoles in the Maxwell photons. For the static Maxwell fields a similar oscillation mechanism can be considered [4].

4 Elliptic and Linear Polarized Photons

Mainly the longitudinal activated photons will be discussed, with the commutators $\mu = 0$ and $\mu = 3$ different from zero. In the relations (2) the correlation structure of the state Z1 of an elliptic polarized O- photon is depicted, with the transversal commutators $\mu = 1$ and $\mu = 2$ equal zero. If we overlap both parts (0/3) and (1/2) of the photon, all correlations will have opposite directions and the overlapping components of the vector potential have the same sign. The longitudinal oscillators activate the cubes by a current flow in all four paths. The paths *gr* and *bu* activate the cubes E_1 with the components A_0 and A_1, and B_2 with the components A_1 and A_3, and the paths *gl* and *bo* the cubes E_2 with components A_2 and A_0, and B_1 with components A_3 and A_2. The photon is elliptic polarized in the fields E_1/B_2 and E_2/B_1.

$$
\begin{array}{ccccccccccccc}
 & & & & B_1 & \leftarrow & {}_{-}A_2 & \rightarrow & E_2 & & & & \\
 & & & & \downarrow & & bo & & \downarrow & & & & \\
 & & & & {}_{+}\mathbf{A}_2 & & & & {}_{+}\mathbf{A}_2 & & & & \\
 & & & & \Uparrow & & & & \uparrow & & & & \\
E_2 & \rightarrow & {}_{+}\mathbf{A}_3 & \leftarrow & \partial A_2 & \Leftarrow & {}_{-}A_2 & \rightarrow & \partial A_0 & \Leftarrow & {}_{-}A_0 & \rightarrow & E_1 \\
\uparrow & & & & \uparrow & & OZ1 & & \Downarrow & & & & \downarrow \\
{}_{-}A_3 & & gl & & {}_{-}A_3 & & 0/3 & & {}_{+}\mathbf{A}_0 & & gr & & {}_{+}\mathbf{A}_0 \\
\downarrow & & & & \Downarrow & & & & \uparrow & & & & \uparrow \\
B_1 & \rightarrow & {}_{+}\mathbf{A}_3 & \Leftarrow & \partial A_3 & \rightarrow & {}_{+}\mathbf{A}_1 & \Leftarrow & \partial A_1 & \leftarrow & {}_{-}A_0 & \rightarrow & B_2 \\
 & & & & \uparrow & & & & \Uparrow & & & & \\
 & & & & {}_{-}A_1 & & & & {}_{-}A_1 & & & & \\
 & & & & \downarrow & & bu & & \downarrow & & & & \\
 & & & & B_2 & \rightarrow & {}_{+}\mathbf{A}_1 & \leftarrow & E_1 & & & &
\end{array}
\tag{2a}
$$

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

$$
\begin{array}{ccccccccccccc}
 & & & & B_1 & \rightarrow & {}_{+}\mathbf{A}_2 & \leftarrow & E_2 & & & & \\
 & & & & \uparrow & & & & \uparrow & & & & \\
 & & & & {}_{-}A_2 & & & & {}_{-}A_2 & & & & \\
 & & & & \Downarrow & & & & \downarrow & & & & \\
E_2 & \leftarrow & {}_{-}A_3 & \rightarrow & \partial A_2 & \Rightarrow & {}_{+}\mathbf{A}_2 & \leftarrow & \partial A_0 & \Rightarrow & {}_{+}\mathbf{A}_0 & \leftarrow & E_1 \\
\downarrow & & & & \downarrow & & OZ2 & & \Uparrow & & & & \uparrow \\
{}_{+}\mathbf{A}_3 & & & & {}_{+}\mathbf{A}_3 & & 0/3 & & {}_{-}A_0 & & & & {}_{-}A_0 \\
\uparrow & & & & \Uparrow & & & & \downarrow & & & & \downarrow \\
B_1 & \leftarrow & {}_{-}A_3 & \Rightarrow & \partial A_3 & \leftarrow & {}_{+}A_1 & \Rightarrow & \partial A_1 & \rightarrow & {}_{+}\mathbf{A}_0 & \leftarrow & B_2 \\
 & & & & \downarrow & & & & \Downarrow & & & & \\
 & & & & {}_{+}\mathbf{A}_1 & & & & {}_{+}\mathbf{A}_1 & & & & \\
 & & & & \uparrow & & & & \uparrow & & & & \\
 & & & & B_2 & \leftarrow & {}_{-}A_1 & \rightarrow & E_1 & & & &
\end{array}
\tag{2c}
$$

$$
\begin{array}{ccccccccccccc}
 & & & & B_1 & \leftarrow & {}_{-}\mathbf{A}_0 & \rightarrow & E_2 & & & & \\
 & & & & \downarrow & & & & \downarrow & & & & \\
 & & & & {}_{+}A_0 & & & & {}_{+}A_0 & & & & \\
 & & & & \uparrow & & & & \Uparrow & & & & \\
E_2 & \rightarrow & {}_{+}A_2 & \Leftarrow & \partial A_2 & \leftarrow & {}_{-}\mathbf{A}_0 & \Rightarrow & \partial A_0 & \leftarrow & {}_{-}\mathbf{A}_1 & \rightarrow & E_1 \\
\uparrow & & & & \Uparrow & & OZ2 & & \downarrow & & & & \downarrow \\
{}_{-}\mathbf{A}_2 & & & & {}_{-}\mathbf{A}_2 & & 1/2 & & {}_{+}A_1 & & & & {}_{+}A_1 \\
\downarrow & & & & \downarrow & & & & \Uparrow & & & & \uparrow \\
B_1 & \rightarrow & {}_{+}A_2 & \leftarrow & \partial A_3 & \Rightarrow & {}_{+}A_3 & \leftarrow & \partial A_1 & \Leftarrow & {}_{-}\mathbf{A}_1 & \rightarrow & B_2 \\
 & & & & \Uparrow & & & & \uparrow & & & & \\
 & & & & {}_{-}\mathbf{A}_3 & & & & {}_{-}\mathbf{A}_3 & & & & \\
 & & & & \downarrow & & & & \downarrow & & & & \\
 & & & & B_2 & \rightarrow & {}_{+}A_3 & \leftarrow & E_1 & & & &
\end{array}
\tag{2d}
$$

Between the two states Z1 and Z2 of the photon in the expressions (2), all correlation directions and all signs of the components of the vector potential are different. If we overlap the correlation structures of the two states, simulating interference, the correlations of the paths of different states and different parts of the photons are parallel and equally directed. Because the signs of the overlapping components of the vector potentials now are different, they interfere destructive. The above elliptic polarized photon is able to interfere, it has "wave" properties. If we exchange all correlation directions of the O-03 photon, we obtain the X-03 photon with the same properties. The photons O-03 and X-03 can be considered as photons of different spin direction. The polarisation of the photon is changed, when the signs of all vector potential components are inverted: all residual currents change their sign.

The photon in the relation (1) is a linear in E_2/B_1 polarized photon. The paths *gr* and *bu* of each state interfere destructive and the included fields E_1 and B_2 are cancelled. The paths *gl* and *bo* have opposite oriented correlation directions, their components of the vector potentials have the same sign; they activate the fields E_2 and B_1. Going to the state Z2, all correlation directions and all signs are changing. The fields E_2 and B_1 change their sign, therefore. With exchange of the state, both fields oscillate in sign. If we overlap both states to simulate interference, namely: the paths of the part (0/3) of state Z1 with the part (1/2) of Z2 and Z2(1/2) with Z1(0/3), they interfere destructive. The linear polarized photon in the representation (1) is able to interfere; it has "wave" properties.

In the same way the linear polarized O-photon E_1/B_2 is obtained. In this photon the paths *bo* and *gl* have the same correlation directions; they interfere destructive and erase the fields E_2 and B_1. The paths *bu* and *gr* have opposite directions, and the signs of the overlapping components of the vector potential are the same. They activate the two paths and the cubes E_1 and B_2. The state Z2 has opposite correlation directions and opposite signs of the vector potential components. An overlap of both states results in a destructive interference.

5 Not Interfering Photons of Light

In the frame of the conditions for the formation of dynamic photons (two sets of positive and two sets of negative components $\{A_\mu, \mu = 0, 1, 2, 3\}$) one also can construct photons, which are not able to interfere, that is, they have "particle" properties. From the elliptic polarized photon in the relation (2), which we have shown, has "wave" properties, one can obtain a photon, which is not able to interfere. For that we exchange the signs in both states of the transversal correlations in the paths $(0/3)bo$ and $(1/2)gl$ for the $\mu = 2$, and in the paths $(0/3)bu$ and $(1/2)gl$ for the $\mu = 1$ oscillator. The photon still fulfils the conditions suggested, the longitudinal oscillators remain active, and the transversal commutators remain zero. The elliptic polarized photon with "particle" properties (3) has in both states all four paths deleted. The dynamic photon with "particle" properties has no activated paths and no activated E- and B- fields therefore; this is for the single photons, as well as for the overlapping photons in two different states. All paths are cancelled: photons become a "particle", they form no interferences and they react with the detector in each state in a same way.

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

$$
\begin{array}{ccccccccccccc}
 & & & & B_1 & \rightarrow & {}_{+}A_0 & \leftarrow & E_2 & & & & \\
 & & & & \uparrow & & & & \uparrow & & & & \\
 & & & & {}_{-}\mathbf{A}_0 & & & & {}_{-}\mathbf{A}_0 & & & & \\
 & & & & \downarrow & & & & \Downarrow & & & & \\
E_2 & \leftarrow & {}_{-}A_2 & \Rightarrow & \partial A_2 & \rightarrow & {}_{+}A_0 & \Leftarrow & \partial A_0 & \rightarrow & {}_{+}\mathbf{A}_1 & \leftarrow & E_1 \\
\downarrow & & & & \Downarrow & & OZ1 & & \uparrow & & & & \uparrow \\
{}_{+}\mathbf{A}_2 & & & & {}_{+}\mathbf{A}_2 & & 1/2 & & {}_{-}A_1 & & & & {}_{-}A_1 \\
\uparrow & & & & \uparrow & & & & \Downarrow & & & & \downarrow \\
B_1 & \leftarrow & {}_{-}A_2 & \rightarrow & \partial A_3 & \Leftarrow & {}_{-}\mathbf{A}_3 & \rightarrow & \partial A_1 & \Rightarrow & {}_{+}\mathbf{A}_1 & \leftarrow & B_2 \\
 & & & & \Downarrow & & & & \downarrow & & & & \\
 & & & & {}_{+}A_3 & & & & {}_{+}A_3 & & & & \\
 & & & & \uparrow & & & & \uparrow & & & & \\
 & & & & B_2 & \leftarrow & {}_{-}\mathbf{A}_3 & \rightarrow & E_1 & & & &
\end{array}
\tag{3b}
$$

Another example for forming photons with "particle" properties can be obtained from the linear polarized interfering E_2/B_1- photon, described by the structure (1), by exchanging the signs of the correlations of the $\mu = 1$ commutator (which is zero). By exchanging the sign in the paths $(0/3)bu$ and $(1/2)gr$, in both states the linear polarized E_2/B_1 photon received "particle" properties. In these examples only the properties of the transversal commutators were changed, which are before and after this manipulation equal zero. To change "wave" properties into "particle" properties, no change in action is needed, and the correlation structure remain the same, as for the wave properties.

In the frame of our formalism we can construct also photons, which have activated only transversal commutators. Starting from the structure of the dynamic vacuum, we obtain an only activated transversal photon, by changing direction and sign of the correlations in the *gl* and *gr* paths of the part (1/2) of the vacuum. The paths *gl* and *gr* overlap constructive in both states, while the *bu* and *bo* paths overlap destructive. The paths *gl* and *gr* have opposite directions and the same sign in each state. The signs change with the change of state. All E- and B- cubes in the paths *gl* and *gr* are activated in both states, and they oscillate in sign (but not form dipoles). They interfere destructive, when both states overlap; the photon has wave properties, but not diffraction properties, because diffraction properties are determined by the the vanishing transversal oscillators, [3].

6 Propagation of Dynamic Photons in Vacuum; Interaction of Photons of Light with Photons of Vacuum

If it is assumed that the vacuum exists in the form deduced for the Maxwell fields in [4], the following oscillation state of a photon of light in vacuum can be simulated under conditions of the PSCO. Under conditions of the PSCO, during formation of a state of a photon to each correlation, another correlation is forming locally and simultaneously in vacuum, with the same current and opposite direction. This correlation simultaneously and locally is compensated by a correlation with opposite direction, and so on, up to limits caused by the fluctuations in vacuum. During the following oscillation state all correlations change their state and the currents forming the action are flowing into the structure of a photon of vacuum, generating the next state of the photon of light. At the same time this process of propagation is continued. In this way each photon is surrounded by a vacuum wave with the properties of the photon of light.

The process of formation of the following oscillation state of a photon of light in vacuum is demonstrated in fig.1. At left in fig.1 the correlation structure of the $\mu = 0$ oscillator of the two overlapped photons O and X and at right in fig.1 the photons of vacuum are shown. The photons of light and of vacuum are overlapping; for a better illustration they are shown in fig.1 separately. In the upper part A-B of fig.1 the oscillation state Z1 of the two photons O and X is shown. The photons of light have in state Z1 positive action in the $\mu = 0$ oscillator and in photons of vacuum the action is deactivated. Photons of vacuum have in state W2 the same correlation directions as the photons O and X of light in state Z1. Due to the formation of the state Z1 of the photons of light together with the state W2 of vacuum at the same time the following oscillation state is formed under conditions of the PSCO. This state is depicted in the middle C-D of fig.1 by the correlation structures of the $\mu = 0$ oscillator for photons of light C and for the photons of vacuum D; their correlation directions are opposite to the directions in state Z1/W2. With the beginning of the oscillation state Z2 of the photon of light C together with the photon of vacuum D in state W1, the following oscillation state Z2/W2 (E-F in fig.1) is formed from the intermediate state Z1a/W1 and the current from state Z1/W2 (A-B in fig.1) is flowing into state Z2/W2 (E-F shown at bottom in fig.1). The new state Z1/W2 (E-F) has the same structure as the original state Z1/W2 (A-B in fig.1), but, due to the oscillation of the signs of currents in the $\mu = 0$ oscillator, action with opposite (negative) sign is formed. The state C-D is an intermediate state of vacuum with action of the vacuum.

The formation of the following oscillation state in vacuum and the flow of currents into the vacuum during the next state we call the *elementary step of induction*; this formation of the following oscillation state under conditions of the PSCO is characteristic for all induction processes. The active dynamic photon structures the surrounding vacuum, by forming its own structure (of opposite state) without action under contribution of the structure of the Maxwell vacuum, and continue itself into the vacuum, fig.2. This follows from the conditions of the PSCO; the formation of an active photon is connected with a simultaneous formation of vacuum photons with the same structure but without action, [3]. The moving photon chooses and forms, under conditions of the PSCO, those strings from the vacuum, which correspond to the structure of its next state. During the formation of the next state the action is, by a flow of currents, transferred into the following structure of the vacuum.

The correlation structures of all Maxwell photons are characterized by two planes: a creator plane and an annihilator plane. In the creator plane all creators and in the annihilator plane all annihilators of the vector potential are located. The two planes are connected with each other by vertical correlations in the cubes. Under the conditions of the PSCO all creators generate simultaneously a current, which flow during the change of state from the creator plane to the annihilator plane, over the vertical correlations in the cubes. In our interpretation of the oscillation behaviour of the photons, the current flowing from the creators to the annihilators, describes the formation of the following state of the photon in vacuum. For the demonstration of the propagation of a O-E_2/B_1-photon with "wave" and "particle" properties in space, two consecutive states Z1 and Z2 of the cubes ∂A_2 and ∂A_0 are shown in fig.2 (the intermediate state C-D of fig.1 is neglected). The μ- correlations of the two commutators $\mu = 0$ and $\mu = 2$ and the connecting strings in the cubes are marked by discontinuous and dot- dashed arrows. The photon is moving from up to down from the state Z1 to the state Z2. The two cubes ∂A_2 and ∂A_0 are connected with μ- and spin correlations (not shown).

For the photon with "wave" properties the two connecting bridges between the two cubes ∂A_2 and ∂A_0 in fig.2 are negative in state Z1 and positive in Z2: this correspond to a negative and a positive sign of the E_2- field. For the photon with "particle" properties the two connecting bridges have different signs in each state; this photon is not forming E_2- fields and cannot form an interfering wave. The development of the photon can be followed, applying the current model and assuming the existence of the vacuum, as described in [4]. In both cubes the current start in state Z1 from a positive and a negative creator of the vector potential component of the cubes ∂A_0 and ∂A_2 (source), passes the string in the cubes and the whole state, and is leaded in a negative and positive annihilator of the cubes ∂A_0 and ∂A_2 (drain), respectively. Note that the currents with

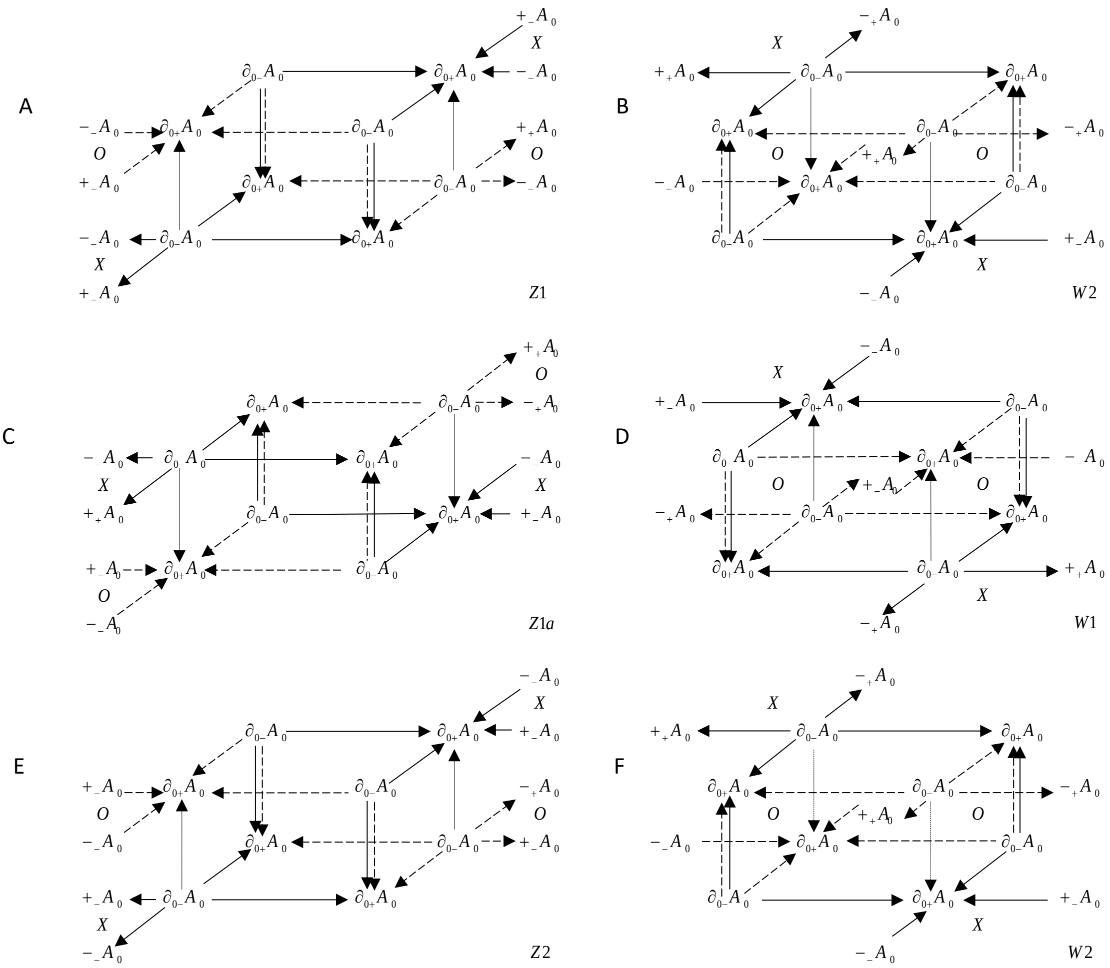

Figure 1: Propagation of the O and X photons of light under interaction with the photons of deactivated vacuum at the example of the $\mu = 0$ oscillator. Left side: photon of light, right: photon of vacuum. Above the photon of light A is creating during its formation the photon of vacuum B in its state W2 and under induction the following state Z2 together with the state W1 of vacuum C-D. In the next oscillation phase from the state Z1/W2 the state Z2 of the photon of light together with the photons of vacuum in state W2 is formed E-F, which has the same structure as state Z1 in A-B, but with opposite signs of currents of state Z2.

different current signs in the ∂A_0 cube have different current circulation directions and in the ∂A_2 cube the currents have the same circulation directions. As a consequence of the state Z1 the drain changes sign and converts into a source and the new state Z2 is generated. In state Z2 the same process in the same direction occurs. The propagation direction of light in vacuum is determined by the flow direction of currents in the correlation structure from creator plane to annihilator plane.

The correlation structure of vacuum photons (C) in fig.1 is the same as that of the activated photon (A); the only difference is that the μ- correlations have in one of the two parts of the active photon the opposite circulation direction. As can be seen in fig.3 the vacuum photons induced locally by the active state of the photon, has opposite correlation directions, formed under the conditions of the PSCO. In the following oscillation state all correlations invert their directions and the current forming the action is flowing into the same structure, with opposite signs of the vector potential components, induced by the change of sign of action in the $\mu = 0$ oscillator. The dynamic photons of vacuum carry structural information, but no action; their propagation is determined by the PSCO and is probably not limited by the rules of special relativity, because vacuum photons are formed from their own virtual action. Vacuum photons can interfere with active photons; this occurs by a superposition of the active photons with coherent vacuum photons: currents from active photons are transferred into the vacuum photons and simultaneously both photons interfere.

The following differences between the dynamic photons with "particle" and with "wave" properties can be derived: In all dynamic photons a current is present in the whole correlation structure, either because of intrinsic oscillation, or by an induction, but some of the currents are cancelled by destructive interference. The interference depends on the sign of the vector potential components and on the circulation direction of currents. The difference between active photons and photons of vacuum is that the currents in the unity cubes are forming a residual current in the active photon, different from zero, while in the vacuum photons these currents have different current signs, but the same circulation directions and are cancelling each other. This is the reason why active photons transport action in the longitudinal oscillators; in the vacuum photons these oscillators are deleted. The active photons with "wave" and with "particle" properties have both in the longitudinal unity cubes residual currents different from zero, but in the photon with "wave" properties also the E- and B- cubes and the connecting spin correlations leads currents different from zero, while these currents are cancelled in the photons with "particle" properties. The E- and B- fields are not oscillating with a residual current in the photons with "particle" properties.

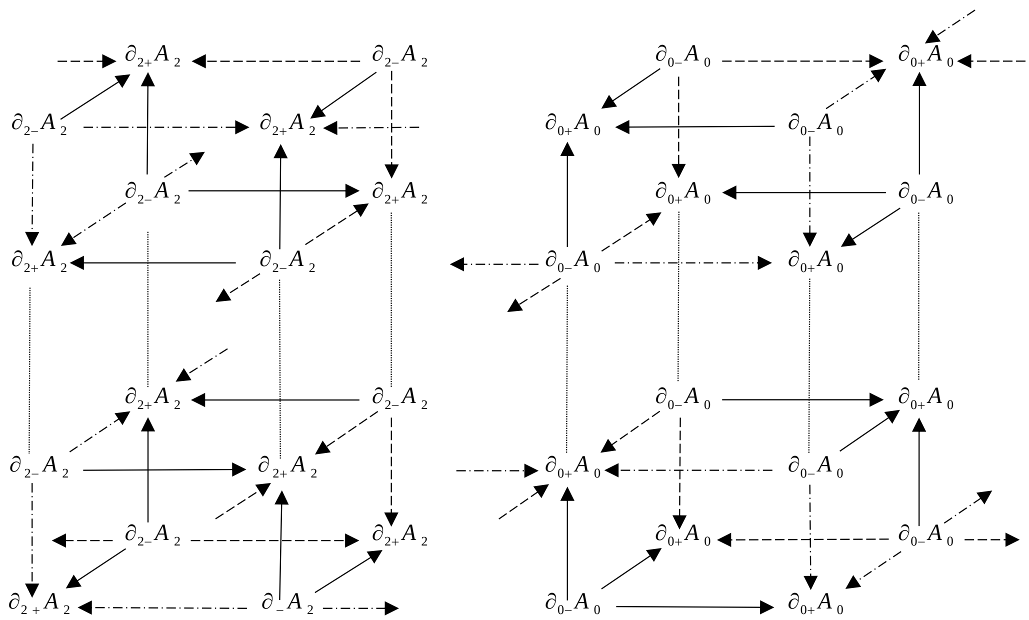

Figure 2: Formation of the state Z2 from the state Z1 of a O- E_2/B_1- photon with "wave" properties, demonstrated at example of the two unity cubes ∂A_2 and ∂A_0.

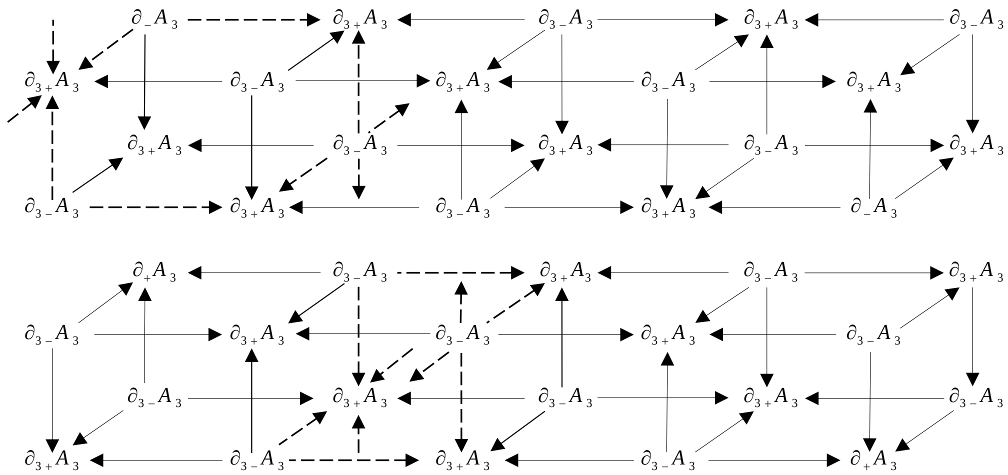

Figure 3: Formation of a vacuum wave train in front of a dynamic Maxwell photon under the conditions of the PSCO and propagation of the action into the formed vacuum photons, illustrated at the example of the ∂A_3-cube. Two consecutive states from up to down are shown. The discontinuous arrows describe the activated currents of the ∂A_3-cube. The photon is moving from left to right.

7 Description of the Correlation Structure in Space Time and Classic Spin

Correlations of the correlation structure of photons of light are determined, transferred into space time and added to form products. Not all products will be reproduce, because of lack of space. We would like to show that it is not possible to obtain products in space time, which completely characterize a single dynamic O- or X- photon. As an example the correlations of the ∂A_3 cube of both photons O and X are reproduced:

O-Z1(0/3): $+_+A_1 \leftarrow \partial_{3-}A_3 + \partial_{3+}A_3 \leftarrow -_-A_1$,
O-Z2(1/2): $+_-A_2 \rightarrow \partial_{3+}A_3 + \partial_{3-}A_3 \rightarrow -_+A_2$,
O-Z1(1/2): $-_+A_2 \leftarrow \partial_{3-}A_3 + \partial_{3+}A_3 \leftarrow +_-A_2$,
O-Z2(0/3): $-_-A_1 \rightarrow \partial_{3+}A_3 + \partial_{3-}A_3 \rightarrow +_+A_1$,

X-Z1(0/3): $+_-A_1 \rightarrow \partial_{3+}A_3 + \partial_{3-}A_3 \rightarrow -_+A_1$
X-Z2(1/2): $+_+A_2 \leftarrow \partial_{3-}A_3 + \partial_{3+}A_3 \leftarrow -_-A_2$
X-Z1(1/2): $-_-A_2 \rightarrow \partial_{3+}A_3 + \partial_{3-}A_3 \rightarrow +_+A_2$
X-Z2(0/3): $-_+A_1 \leftarrow \partial_{3-}A_3 + \partial_{3+}A_3 \leftarrow +_-A_1$

No products can be formed from correlations of one of the two single photons O or X. Only when we add the correlations of both photons O and X, the following products are obtained in space time:

Z1(0/3): $[A_1, \partial_3 A_3]$ Z1(1/2): $[A_2, \partial_3 A_3]$
Z2(0/3): $[\partial_3 A_3, A_1]$ Z2(1/2): $[\partial_3 A_3, A_2]$

The correlations added between the two photons O and X, and added between the two states, gives zero. The vanish of contributions in space- time can be expected in a rest frame. A similar result is obtained for the spin correlations of the E and B cubes. This is demonstrated at the example of the cubes E_2 and B_1:

O-Z1(1/2)bo:
B_1: $-_+A_0 \leftarrow \partial_{2-}A_3 + \partial_{2+}A_3 \leftarrow +_-A_0$
E_2: $+_-A_0 \rightarrow \partial_{0+}A_2 + \partial_{0-}A_2 \rightarrow -_+A_0$
O-Z2(1/2)bo:
B_1: $+_-A_0 \rightarrow \partial_{2+}A_3 + \partial_{2-}A_3 \rightarrow -_+A_0$
E_2: $-_+A_0 \leftarrow \partial_{0-}A_2 + \partial_{0+}A_2 \leftarrow +_-A_0$
O-Z1(0/3)gl:
B_1: $-_-A_3 \rightarrow \partial_{2+}A_3 + \partial_{2-}A_3 \rightarrow +_+A_3$
E_2: $+_+A_3 \leftarrow \partial_{0-}A_2 + \partial_{0+}A_2 \leftarrow -_-A_3$
O-Z2(0/3)gl:
B_1: $+_+A_3 \leftarrow \partial_{2-}A_3 + \partial_{2+}A_3 \leftarrow -_-A_3$
E_2: $-_-A_3 \rightarrow \partial_{0+}A_2 + \partial_{0-}A_2 \rightarrow +_+A_3$

X-Z1(1/2)bo:
B_1: $-_-A_0 \rightarrow \partial_{2+}A_3 + \partial_{2-}A_3 \rightarrow +_+A_0$
E_2: $+_+A_0 \leftarrow \partial_{0-}A_2 + \partial_{0+}A_2 \leftarrow -_-A_0$
X-Z2(1/2)bo:
B_1: $+_+A_0 \leftarrow \partial_{2-}A_3 + \partial_{2+}A_3 \leftarrow -_+A_0$
E_2: $-_-A_0 \rightarrow \partial_{0+}A_2 + \partial_{0-}A_2 \rightarrow +_-A_0$
X-Z1(0/3)gl:
B_1: $-_+A_3 \leftarrow \partial_{2-}A_3 + \partial_{2+}A_3 \leftarrow +_-A_3$
E_2: $+_-A_3 \rightarrow \partial_{0+}A_2 + \partial_{0-}A_2 \rightarrow -_+A_3$
X-Z2(0/3)gl:
B_1: $+_-A_3 \rightarrow \partial_{2+}A_3 + \partial_{2-}A_3 \rightarrow -_+A_3$
E_2: $-_+A_3 \leftarrow \partial_{0-}A_2 + \partial_{0+}A_2 \leftarrow +_-A_3$

Addition between two photons O and X and the two states results in

$$
\begin{aligned}
\mathrm{B}_1: \quad & -A_0\partial_2 A_3 + \partial_2 A_3 A_0 + A_0\partial_2 A_3 - \partial_2 A_3 A_0 \\
& -A_3\partial_2 A_3 + \partial_2 A_3 A_3 + A_3\partial_2 A_3 - \partial_2 A_3 A_3 = 0 \\
\mathrm{E}_2: \quad & +A_0\partial_0 A_2 - \partial_0 A_2 A_0 - A_0\partial_0 A_2 + \partial_0 A_2 A_0 \\
& +A_3\partial_0 A_2 + \partial_0 A_2 A_3 - A_3\partial_0 A_2 - \partial_0 A_2 A_3 = 0
\end{aligned}
$$

The contribution of both photons and both states is reduced to zero. The classical spin of both photons O and X for the field E_2 is $S_1 = [\partial_0 A_2, A_3] + [A_3, \partial_0 A_2] = 0$. It is the contribution of the second state, in addition to both photons with opposite spins, which leads to a sum equal zero. The commutators for the spin are a result of an overlap of the contribution of correlations from both photons O and X and both states. It is the difference of the correlations in the paths O-Z1(0/3)*gl* and X-Z1(0/3)*gl*, which form the classical spin. The currents in the paths formed by the correlations, describe the difference of the two photons O and X and not the products in space time.

In our formalism we can characterize the classical spin by the sign of the current and the sign of the current circulation direction. For the classical spin S1 in the path *gl* for the cube E_2 of the O- Photon in the correlation structure (2) the currents are in state Z1 described by $(0/3)/(1/2) = (--)/(++)$ and in the state Z2 by $(-+)/(+-)$, while the same spin in the X- photon in state Z1 is given by $(++)/(--)$ and in Z2 by $(+-)/(-+)$. The first sign in the brackets is the sign of the current and the second sign the sign of the current circulation direction. The residual current in both photons O and X in the E_2 cube is the same, characterizing the same action. Both photons are distinguished from each other by the current of a special correlation. This is only locally the case, however; the currents have different directions for different correlations in the photon, and especially they do not surround the whole photon; but all currents in the two photons have different circulation directions. The different spin direction is illustrated in fig.4 by the two oscillation states of the ∂A_3 oscillator, in which the currents of the two photons of light O and X with the same propagation direction are introduced. The two to each other assigned correlations have the same current sign, but opposite current directions.

If we change the signs of all vector potential components in the correlation structure of the photon, the residual currents will be inverted. The photons with opposite signs, but the same circulation direction, describe two different polarization directions - in addition to the polarization defined by the photons E_1/B_2 and E_2/B_1. With the change of signs of components of the vector potential also the sign of action is changed in both oscillation states.

8 Entangled Photons

Entanglement is obtained in our formalism, if photons with different properties, for example the spin directions, are overlapped. The entanglement is promoted by the "principle

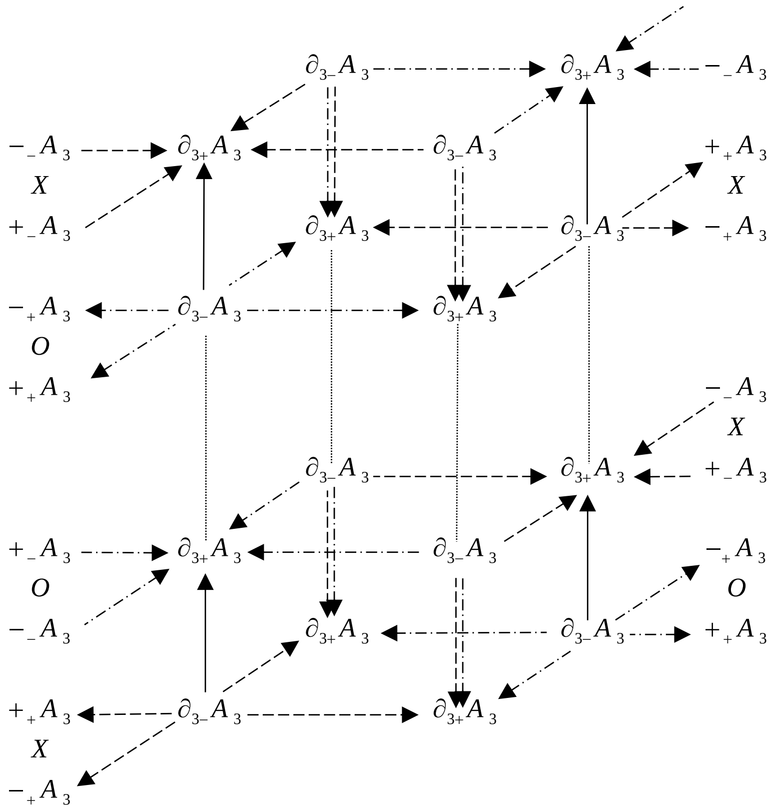

Figure 4: The two oscillation states of the ∂A_3 oscillator of dynamic photons of light, in which the currents of the two photons O and X are introduced, showing the different current directions for these two photons; The O and X photons propagate from state Z2 in the upper part to state Z1 at the lower part in fig.4.

of simultaneous contrary oscillation" (PSCO). This principle is part of the demand that in a rest frame the action of a system must vanish, and it is equivalent to the validity of the third law of Newton in an oscillator, located in a rest frame. In [3] entanglement of two photons is defined by an overlap of currents with the same current directions under formation of a residual current, under reduction of action and the formation of a common vacuum train of the two photons. In contradiction to entanglement two photons can be overlapped without an addition of currents, from this photons we will speak of being superimposed. They contribute to a broadening of the halve width.

In addition to the linear polarized photon O-03-E_2/B_1 depicted in the structure (1) we construct the photon X-03-E_2/B_1 with the inverse spin direction, shown by the structure (4). The paths *bo* and *gl* form in both photons the activated fields E_2 and B_1. Overlapping both photons O and X in the same state, the path O-*bo*(0/3) overlap constructive with the path X-*bo*(1/2), and the path O-*gl*(0/3) overlap constructive with the path X-*gl*(1/2). (The paths *bu* and *gr* are cancelled in each of the photons O and X.) This results for both states. The entangled photons O and X form a new unit, with new properties, according to quantum mechanics the single photons cannot be distinguished any more. This is illustrated in fig.4. From the correlation structure reveals, however, that the two photons O and X in entanglement can be distinguished on Fourier space.

$$
\begin{array}{ccccccccccccc}
 & & & & B_1 & \rightarrow & {}_{+}A_2 & \leftarrow & E_2 & & & & \\
 & & & & \uparrow & & bo & & \uparrow & & & & \\
 & & & & {}_{-}\mathbf{A}_2 & & & & {}_{-}\mathbf{A}_2 & & & & \\
 & & & & \Downarrow & & & & \downarrow & & & & \\
E_2 & \leftarrow & {}_{-}\mathbf{A}_3 & \rightarrow & \partial A_2 & \Rightarrow & {}_{+}A_2 & \leftarrow & \partial A_0 & \Rightarrow & {}_{+}A_0 & \leftarrow & E_1 \\
\downarrow & & & & \downarrow & & XZ1 & & \Uparrow & & & & \uparrow \\
{}_{+}A_3 & & gl & & {}_{+}A_3 & & 0/3 & & {}_{-}\mathbf{A}_0 & & gr & & {}_{-}\mathbf{A}_0 \\
\uparrow & & & & \Uparrow & & & & \downarrow & & & & \downarrow \\
B_1 & \leftarrow & {}_{-}\mathbf{A}_3 & \Rightarrow & \partial A_3 & \rightarrow & {}_{+}A_1 & \Leftarrow & \partial A_1 & \rightarrow & {}_{+}A_0 & \leftarrow & B_2 \\
 & & & & \uparrow & & & & \Uparrow & & & & \\
 & & & & {}_{-}\mathbf{A}_1 & & & & {}_{-}\mathbf{A}_1 & & & & \\
 & & & & \downarrow & & bu & & \downarrow & & & & \\
 & & & & B_2 & \rightarrow & {}_{+}A_1 & \leftarrow & E_1 & & & &
\end{array}
\tag{4a}
$$

$$
\begin{array}{ccccccccccccc}
 & & & & B_1 & \leftarrow & {}_{-}A_0 & \rightarrow & E_2 & & & & \\
 & & & & \downarrow & & & & \downarrow & & & & \\
 & & & & {}_{+}\mathbf{A}_0 & & & & {}_{+}\mathbf{A}_0 & & & & \\
 & & & & \uparrow & & & & \Uparrow & & & & \\
E_2 & \rightarrow & {}_{+}\mathbf{A}_2 & \Leftarrow & \partial A_2 & \leftarrow & {}_{-}A_0 & \Rightarrow & \partial A_0 & \rightarrow & {}_{+}\mathbf{A}_1 & \leftarrow & E_1 \\
\uparrow & & & & \Uparrow & & XZ1 & & \uparrow & & & & \uparrow \\
{}_{-}A_2 & & & & {}_{-}A_2 & & 1/2 & & {}_{-}A_1 & & & & {}_{-}A_1 \\
\downarrow & & & & \downarrow & & & & \Downarrow & & & & \downarrow \\
B_1 & \rightarrow & {}_{+}\mathbf{A}_2 & \leftarrow & \partial A_3 & \Rightarrow & {}_{+}\mathbf{A}_3 & \leftarrow & \partial A_1 & \Rightarrow & {}_{+}\mathbf{A}_1 & \leftarrow & B_2 \\
 & & & & \Uparrow & & & & \uparrow & & & & \\
 & & & & {}_{-}A_3 & & & & {}_{-}A_3 & & & & \\
 & & & & \downarrow & & & & \downarrow & & & & \\
 & & & & B_2 & \rightarrow & {}_{+}\mathbf{A}_3 & \leftarrow & E_1 & & & &
\end{array}
\tag{4b}
$$

In a similar way we obtain the entangled O and X photons 03-E_1/B_2, and entangled elliptic polarized photons [3]. If the photons O and X overlap with the same state, the entangled photons O and X are able to interfere, because the currents add constructive; if they overlap with different states and when their currents (their action) are the same, they interfere destructive and cancel each other.

9 Bell States of Entangled Photons

The entangled photons O-E_2/B_1 in (1) and X-E_2/B_1 in (4) are considered, which have active paths *bo* and *gl*, and deactivated paths *bu* and *gr*. Each state of the photon consists of two parts (0/3) and (1/2), which μ- correlations have in different states opposite signs. In the state Z1 the sign of the $\mu = 0$ commutator is positive and in Z2 negative. In part O-Z1(0/3) the μ- correlations have a positive and in part Z1(1/2) a negative circulation direction (clockwise). The X- photon have the same signs of commutators, and inverse circulation directions of the μ- correlations. The two photons O and X may form an entanglement, and we want to derive the Bell states of these two photons. We choose the circulation direction of the μ- commutators to describe the entanglement of the photons. In the path *gr* of the O(0/3)-photon part, the μ- correlations have a positive circulation direction, which we assign by $|0\rangle$, and for the negative circulation direction we choose $|1\rangle$. Both photons O and X are abbreviated by 1 and 2, respectively. In the state Z1 the overlap of the two photons in the path $gr(0/3)$ is included in Z1-O&Z1-X, what is described by $|0\rangle_1|1\rangle_2$, the state Z2 of the same path results in Z2-O&Z2-X, this is the state $|1\rangle_1|0\rangle_2$. The two states Z1 and Z2 of the correlation structure describes the Bell state $\Psi^{\pm} = |0\rangle_1|1\rangle_2 \pm |1\rangle_1|0\rangle_2$. If we overlap the paths of two different states of the photons, for example $gr(0/3)$: Z1-O&Z2-X, this results in $|0\rangle_1|0\rangle_2$ and for Z2-O-Z1-X we obtain $|1\rangle_1|1\rangle_2$. This describes the Bell state $\Phi^{\pm} = |0\rangle_1|0\rangle_2 \pm |1\rangle_1|1\rangle_2$.
As an example of the allocation of the correlation structure to the Bell states in the following the paths $(0/3)gr$ are shown:

$$
\begin{array}{ccccc@{\qquad}ccccc}
\partial A_0 & \Leftarrow & {}_{-}A_0 & \rightarrow & E_1 & \partial A_0 & \Leftarrow & {}_{-}\mathbf{A}_0 & \rightarrow & E_1 \\
\Downarrow & & OZ1 & & \downarrow & \Downarrow & & XZ2 & & \downarrow \\
{}_{+}\mathbf{A}_0 & & gr & |0\rangle_1 & {}_{+}\mathbf{A}_0 & {}_{+}A_0 & & gr & |0\rangle_2 & {}_{+}A_0 \\
\uparrow & & 0/3 & & \uparrow & \uparrow & & 0/3 & & \uparrow \\
\partial A_1 & \leftarrow & {}_{-}A_0 & \rightarrow & B_2 & \partial A_1 & \leftarrow & {}_{-}\mathbf{A}_0 & \rightarrow & B_2
\end{array}
$$

$$
\begin{array}{ccccc@{\qquad}ccccc}
\partial A_0 & \Rightarrow & {}_{+}A_0 & \leftarrow & E_1 & \partial A_0 & \Rightarrow & {}_{+}\mathbf{A}_0 & \leftarrow & E_1 \\
\Uparrow & & XZ1 & & \uparrow & \Uparrow & & OZ2 & & \uparrow \\
{}_{-}\mathbf{A}_0 & & gr & |1\rangle_2 & {}_{-}\mathbf{A}_0 & {}_{-}A_0 & & gr & |1\rangle_1 & {}_{-}A_0 \\
\downarrow & & 0/3 & & \downarrow & \downarrow & & 0/3 & & \downarrow \\
\partial A_1 & \rightarrow & {}_{+}A_0 & \leftarrow & B_2 & \partial A_1 & \rightarrow & {}_{+}\mathbf{A}_0 & \leftarrow & B_2
\end{array}
$$

The Bell states are $\Psi^- = |0\rangle_1|1\rangle_2 - |1\rangle_1|0\rangle_2$, or $\Phi^+ = |0\rangle_1|0\rangle_2 + |1\rangle_1|1\rangle_2$. For the signs of the products in the Ψ- Bell states the sign of the $\mu = 0$ commutator was chosen. The overlap of different states forming the Φ- Bell states is destructive and reduces all commutators to zero, when the amount of action is the same in both photons O and X. The formation of the Bell states Ψ^- is constructive under formation of a positive $\mu = 0$ oscillator in $|0\rangle_1|1\rangle_2$ and a negative in $|1\rangle_1|0\rangle_2$.

10 Summary and Discussion

From the trace of the energy-momentum tensor of Maxwell fields and from covariant four dimensional commutators of communication relations of quantum mechanics (μ-commutators) [5] correlations on Fourier space are obtained. The correlations, [2], are used for a construction of structures of photons of light with oscillator properties. The μ-commutators are interpreted as sources of action. Linear polarized photons E_1/B_2 and E_2/B_1 and elliptic polarizes photons are obtained; their particle and wave properties are shown in dependence from the signs of the transversal oscillators. Wave properties are described by interference of the two oscillation states and diffraction properties follow from the deactivation of the transversal oscillators. In particle properties the currents are annihilated in the E- and B-fields and the two oscillation states have the same properties. Entanglement is simulated by superposition of two photons with different properties and the two Bell states are constructed. The propagation of the photons in vacuum is described by induction and formation of vacuum waves under conditions of the PSCO. The properties of the photons of light, as the spin, the wave and particle behaviour, the entanglement, their relation to Bell states and the propagation of light in vacuum are described by a common correlation structure with two positive and two negative sets of components of the vector potential $\{A_\mu, \mu = 0, 1, 2, 3\}$ and the ∂A_α, E_i and B_i cubes obtained from the trace of the energy momentum tensor. Different behaviour of the photons is obtained by changing the signs of components of the vector potential or by a change of the correlation directions.

The formation of E- and B- fields in the structure of the photon, can be discussed by the interference of the paths of the two overlapping parts (0/3) and (1/2). If the correlations of the two overlapping parts of the photons are parallel and equally directed, and if the signs of the vector potential components in the paths are the same, they interfere constructive, they interfere destructive, when the signs are different. Using this rule one can construct elliptic polarized photons with activated fields E_2/B_1 and E_1/B_2. This assumption is supported by the oscillation model of the paths, which show that E_i and B_i cubes are always contain residual currents different from zero, when action is activated.

The elliptic and linear in E_1/B_2 or in E_2/B_1 polarized photons oscillate by changing sign of the vector potential components and directions of correlations between the two states, and have "wave" properties. This can be shown by overlapping the two states of the photon: the activated paths interfere destructive. The "wave" properties can be transferred into "particle" properties. For the linear polarized E_2/B_1 photon with wave properties, this can be simple obtained, by changing the signs of the $\mu = 1$ vector potential components. A similar procedure can be performed with the elliptic polarized photon, by changing the signs in both states of both transversal components of the vector potential. Changing the signs of the transversal μ- correlations, which sum is zero before and after this manipulation, transfers the photon from "wave" to "particle" properties. This shows that one can change "wave" properties of photons into "particle" properties, even without changing the activity of the longitudinal commutators. The "wave" and "particle" properties are ruled by details of the structure of the photon.

If interference is simulated by overlapping two different states of both linear polarized photons E_1/B_2 and E_2/B_1, they do not cancel each other, although they have wave properties. In the E_1/B_2 photon only the paths *gr* and *bu*, and in the photon E_2/B_1 only the paths *bo* and *gl* are active. This is the reason, why in the "which way" experiment no interference pattern can be observed, when we use those polarized photons for the illumination of the two slits, [6]. For a discussion of details see [3].

From the correlation structure of the dynamic photons, the classic spin can be determined. The classic spin is formed by correlations adjoining the E_1 cube of the path $(1/2)bu$, and the E_2 cube of path $(0/3)gl$. The correlations of a single photon O or X cannot be added to form products, even if we use both states. They form products in the space time, when the correlations of both photons O and X are used. For the field E_1 in Z1 a spin of $S_2 = [\partial_0 A_1, A_3]$ and for E_2 in Z1 a spin $S_1 = [\partial_0 A_2, A_3]$ is obtained. If we determine the spin of the next state, the signs of the commutator change. One can distinguish the spin of both photons O and X only by the direction of correlations, which are different in both photons. The present discussion of the spin occurs in a rest frame that means without any interaction. If measuring the spin with an in-elastic interaction is performed, different results must be expected.

The movement of dynamic photons in vacuum is determined by the propagation of action, and occurs under the conditions of the PSCO. The action propagates during the change of states by the oscillation of the photons and occurs with the speed of light. The

PSCO demand a simultaneous and local formation of vacuum photons during the formation of a state of an active photon, and is not connected with the transport of action: vacuum photons carry only deactivated virtual action, [4] and structure information in the transversal oscillators. The transversal oscillators are responsible for diffraction and interference. The formation of wave trains, without action, which move in front of the active dynamic photons, is based on the induction: during formation of a state of an active photon, simultaneously a wave train is formed in front of the photons under conditions of the PSCO and in the next oscillation state currents are flowing into the locally present vacuum photon. Photons are not able to fulfil completely the PSCO, because the currents in the consecutive states have always the same direction (compare fig.1). The propagation of light in Maxwell vacuum is independent in relation to a rest frame, because the photons form their own structures by induction under application of the correlation structure of the vacuum, [3].

The interference between the active photon with wave properties and the vacuum photons, travelling in front of the active photon, occurs between the transversal oscillators, which have no action. Prove of the interference pattern by an interaction with a detector is nevertheless possible, because in dynamic photons the transversal and longitudinal correlations overlap with equally directed correlations. In photons of static Maxwell fields with wave properties the interference occurs with longitudinal oscillators.

The entanglement of dynamic photons is in our formalism a consequence of the tendency of reduction of action (Hamilton principle). At the example of the two entangled E_2/B_1- photons O and X it is shown that from the correlations structure the Bell states can be derived. For that we use the circulation direction, the sign of the $\mu = 0$ oscillator and the two states of the photon. If one combine both states to form the $\Phi^{\pm}$ states, all correlations overlap destructive. Using the presented model for the characterization of Maxwell photons it is shown in [7] that the entanglement in EPR experiments can be interpreted by the formation of wave trains, connecting two entangled photons.

In the theory of S.N. Gupta and K. Bleuler, [8], the energy of the photons is described by the transversal degrees of freedom, while the longitudinal components are considered to have opposite sign, and cancel each other. In our formalism we are able to construct longitudinal, as well as transversal activated dynamic photons. From the results of the whole formalism follows that the longitudinal part of the photons describe the action, consisting of energy and momentum, and that the transversal commutators describe the elastic interaction, contain structural properties, and have no action. As in the theory of S.N. Gupta and K. Bleuler, in each state the two longitudinal commutators have opposite signs. Because the longitudinal commutator describe in our formalism the in- elastic interaction for the static photons, and this interaction is always connected with an opposite sign of the two longitudinal commutators, while the elastic interaction is caused by the transversal commutators, the longitudinal commutators should characterize the action that is also the energy of the photons of light. There are at present no arguments that photons with four dimensional activated oscillators or only with transversal activated oscillators cannot be part of light, however.

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