Wave-Particle Dualism

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Abstract: Representing photons of light and photons of static Maxwell fields by correlation structures the wave-particle dualism can be described as a change of properties of the structures of photons between wave and particle behaviour. In material waves the properties of the photons of static Maxwell fields determine also the wave and particle properties of the material-oscillators.

1 Introduction

A method was developed for a description of elementary particles by structures with oscillator properties. The representations of the elementary objects by the Lagrange density and by commutators of communication relations of quantum mechanics are transformed into Fourier space and the obtained correlations, [1], are used for the construction of correlation structures of elementary objects, such as photons of Maxwell fields and of simple scalar oscillators of charges. In this way not a single field is describing an elementary objects, but all fields forming the Lagrange density and the commutators of communication relations represent the object.

The correlation structures are formed under conditions of the third law of Newton; they exists always in two representations, which are distinguished from each other by the direction of correlations. The two structures with different correlation directions and the same signs of correlations can be interpreted as two spin directions O and X, and changing in addition some signs of the correlations between the two representations, the structures can be interpreted as two oscillation states Z1 and Z2 of an oscillator. The objects are characterized by physical information, which is action embedded in a four dimensional oscillator. The physical information is characterizing the objects, is exchanged between the objects and describes the changed properties of objects after an interaction. Formation of structures of oscillators, their characterization and the description of interaction occurs under conditions of action minimization (Principle of Hamilton). Applying the representation of the elementary objects as correlation structures with oscillator properties, the "quantum mechanical effects" can be interpreted by locality and causality, [2].

This will be discussed in the present paper for the wave particle dualism of photons of light and of material waves.

2 Wave-Particle Dualism of Photons of Light

From the general correlation structure of Maxwell fields, as developed from the trace of the energy-momentum tensor and from covariant four dimensional commutators of communication relations of quantum mechanics, [3],both represented by the components of the vector potential, two different correlation structures are obtained, which can be identified by structures of photons of light and of structures of photons of static Maxwell fields. First the particle and wave properties of photons of light will be discussed.

In relations (1) the correlation structure of the O-photon of light in its oscillation state Z1 is shown.

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

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

The Maxwell photons are formed from two parts (1/2) and (0/3); the two parts must be overlap for their interpretation (For a better visualization they are depicted in (1) separately.). The correlation structure of light consists of two positive and two negative sets of the vector potential $\{A_\mu, \mu = 0, 1, 2, 3\}$ and of the cubes E_i, B_i and ∂A_μ, which are obtained from the trance of the energy-momentum tensor and which describes the E_i and B_i fields; ∂A_μ are the unity cubes describing the unities of the components of the vector potential. The arrows describe correlations; they are directed from the creator to the annihilator. The double arrows describe the correlations of the commutators of communication relations of quantum mechanics and the single arrows spin correlations. The positive components of the vector potential are described by bolt letters, the other vector components are negative. The oscillation behaviour of the correlation structures of Maxwell photons can be interpreted, if it is assumed that the $\mu = 0$ oscillator is the source of oscillation, forced by currents flowing during the change of state from a creator $_-A_\mu$ to an annihilator $_+A_\mu$. The currents flow always from a positive or negative creator to an negative or positive annihilator, respectively. The current sign is determined by the sign of the creator. The currents can flow in positive or negative circulation direction in the path of the photon; the residual current is determined in relation to the negative circulation direction (clockwise). In a rest frame currents have in the whole structure the same amount, parallel currents with the same direction and different current signs, cancel each other, therefore.

The correlation structures of Maxwell fields consists of two plans: the creator plane consisting of all creators and an annihilator plane, consisting of all annihilators. During a change of state current of all creators of the creator plane are flowing to all annihilators of the annihilator plane. Correlation structures of photons of light describe the experimentally known properties, if the longitudinal oscillators of the photons are activated and the transversal oscillators are deactivated (which is in some contradiction to the theory of S.N. Gupta and K. Bleuler, [4]; discussion in [2]).

The O-photon in (1) is an elliptic polarized photon, which can be proved by showing that in all four cubes E_i, B_i the currents are different from zero (Two currents with the same current direction annihilate each other when they have different current signs.). From the elliptic polarized photon the linear polarized photon E_2, B_1 is obtained, when we change the signs and correlation directions in the paths $(0/3)bu$ and $(1/2)gr$ and similar the linear polarized photon E_1, B_2 is obtained from the elliptic polarized photon (1) if we change the signs of components of vector potential and correlation directions in the paths $(0/3)bo$ and $(1/2)gl$ (Changing signs and correlations directions the number of components of the vector potential is not changing.)

The cubes consists of twelve correlations between the partial derivatives of the vector potential. For the two oscillation states of the E_i cubes this is shown in fig.1. In fig.2 the two oscillation states of the unity cubes for the μ= 0 oscillator of the O and X photons of light are shown. To the unity cubes the correlations of the commutators of communication relations are added. Each of the two photons O and X contain one covariant four dimensional commutator. In fig.2 the two $\mu = 0$ commutators of the photons O and X of light are introduced. The correlations at unity cubes with double arrows in (1) can be identified with the currents of quantum mechanics, [2]. The currents generated by

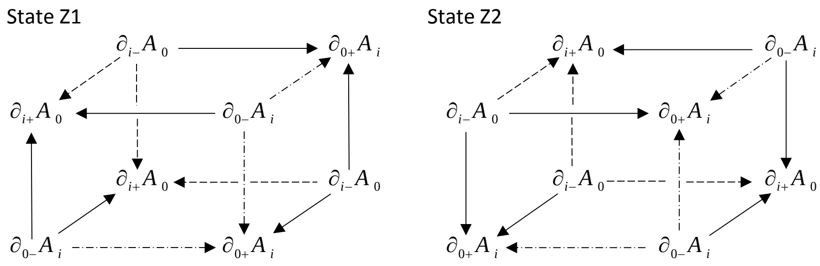

Figure 1: Two oscillation states of the E_i cubes. The correlations describing the photons of light are marked by continuous arrows. The other arrows describe the correlations of static Maxwell fields.

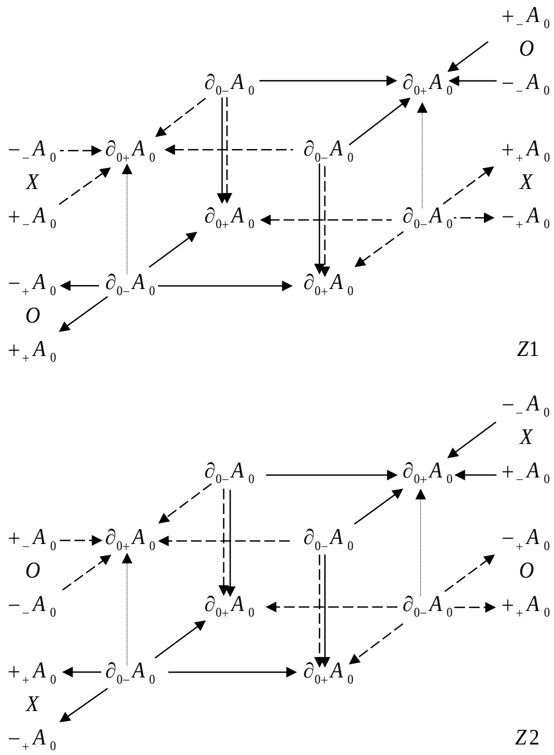

Figure 2: Two oscillation states of the O and X photons of light: Z1 positive, Z2 negative action in the $\mu = 0$ oscillator. The discontinuous arrows describe the currents of the O-photon and the continuous arrows the currents of the X-photon. The state Z2 is formed from state Z1 by induction; overlapping both states all currents annihilate each other.

two creators $_{-}A_0$ with positive and negative sign are leading over the unity cube ∂A_0 to the two annihilators $_{+}A_0$ with negative and positive sign, respectively. For each photon O and X in each oscillation state a commutator of communication relations is defined, for the state Z1 the commutator $[A_0, \partial A_0]$ and for Z2 the commutator $[\partial A_0, A_0]$, which we interpret as the generation of positive and negative action of the $\mu = 0$ oscillator. The amount of generated action (number of action units) determine the frequency of the photon of light. The creators in the creator plan generate a current, which flow between each halve phase of oscillation to the annihilators of the annihilator plan. The flow of current between the creator plan to the annihilator plane is also the propagation direction of the photon in space time.

The second oscillation state of the photon (1) is obtained, when in (1) all correlation directions and all signs of vector potential are inverted. Obviously, if the two oscillation states of the same photons are overlapped in the form OZ1(1/2) with Z2(0/3) and OZ1(0/3) with OZ2(1/2) all currents are annihilated. Overlapping the two phases of the O-photons interference is simulated: the photons (1) has wave properties.

From the photon with wave properties (1) the photon with particle properties (2) is simple obtained by changing in both oscillation states the transversal correlations in the paths $(0/3)bo$ and $(1/2)gl$ for the $\mu = 2$ oscillator, and in the paths $(0/3)bu$ and $(1/2)gl$ for the $\mu = 1$ oscillator. The oscillation state Z1 of the O-photon with particle properties is shown in the relations (2).

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

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

Because the photons of light consists of two positive and two negative sets of components of the vector potential $\{A_\mu, \mu = 0,1,2,3\}$ the change of signs of the transversal components of the vector potential in the correlation structure, which action is deactivated, will not change the constitution of the photon. The obtained photon has in both oscillation states all paths deactivated, the photon cannot interfere and has in both oscillation states the same properties: it has particle properties. In an interaction of photons with wave properties (1) a change into a photon with particle properties occurs simply by a change of the signs of the transversal components of the vector potential; for a transfer from wave into particle properties no change of action is needed.

3 Particle Properties of Static Maxwell Fields

For a discussion of the wave-particle dualism of material waves the wave and particle properties of photons of static Maxwell fields, the wave and particle properties of material oscillators and the interaction of the static photons with the materials oscillators must be considered. First the correlation structure of the photons of static Maxwell fields are discussed. The photons of static Maxwell fields have a different correlation structure in comparison to to the correlation structure of photons of light. They consists of O-X-photons, a combination of the two static photons O and X with different spin directions. As an example in relations (3) the structure of the static O-photon of photons of a positive charge in state Z1 in particle properties is depicted.

$$
\begin{array}{ccccccccccccc}
B_3 & \rightarrow & {}_{+}\mathbf{A}_1 & \leftarrow & B_1 & & & & E_2 & \rightarrow & {}_{+}\mathbf{A}_0 & \leftarrow & E_3 \\
\uparrow & & & & \uparrow & & & & \uparrow & & & & \uparrow \\
{}_{-}A_1 & & LO & & {}_{-}A_1 & & & & {}_{-}A_0 & & RO & & {}_{-}A_0 \\
\downarrow & & & & \downarrow & & & & \Downarrow & & & & \downarrow \\
E_2 & \rightarrow & {}_{+}\mathbf{A}_1 & \leftarrow & \partial A_2 & \Leftarrow & {}_{-}A_2 & \rightarrow & \partial A_0 & \Rightarrow & {}_{+}\mathbf{A}_0 & \leftarrow & E_1 \\
 & & & & \Downarrow & & OZ1 & & \downarrow & & & & \\
 & & & & {}_{+}\mathbf{A}_2 & & 1/2 & & {}_{+}\mathbf{A}_1 & & & & \\
 & & & & \uparrow & & +0123 & & \Uparrow & & & & \\
B_1 & \rightarrow & {}_{+}\mathbf{A}_3 & \Leftarrow & \partial A_3 & \leftarrow & {}_{-}A_1 & \Rightarrow & \partial A_1 & \rightarrow & {}_{+}\mathbf{A}_2 & \leftarrow & B_2 \\
\uparrow & & & & \Uparrow & & & & \uparrow & & & & \uparrow \\
{}_{-}A_3 & & LU & & {}_{-}A_3 & & & & {}_{-}A_2 & & RU & & {}_{-}A_2 \\
\downarrow & & & & \downarrow & & & & \downarrow & & & & \downarrow \\
E_3 & \rightarrow & {}_{+}\mathbf{A}_3 & \leftarrow & B_2 & & & & E_1 & \rightarrow & {}_{+}\mathbf{A}_2 & \leftarrow & B_3
\end{array}
\tag{3a}
$$

$$
\begin{array}{ccccccccccccc}
B_3 & \rightarrow & {}_{+}A_2 & \leftarrow & B_1 & & & & E_2 & \rightarrow & {}_{+}A_3 & \leftarrow & E_3 \\
\uparrow & & & & \uparrow & & & & \uparrow & & & & \uparrow \\
{}_{-}\mathbf{A}_2 & & & & {}_{-}\mathbf{A}_2 & & & & {}_{-}\mathbf{A}_3 & & & & {}_{-}\mathbf{A}_3 \\
\downarrow & & & & \Downarrow & & & & \downarrow & & & & \downarrow \\
E_2 & \rightarrow & {}_{+}A_2 & \Leftarrow & \partial A_2 & \leftarrow & {}_{-}\mathbf{A}_0 & \Rightarrow & \partial A_0 & \rightarrow & {}_{+}A_3 & \leftarrow & E_1 \\
 & & & & \downarrow & & OZ1 & & \Downarrow & & & & \\
 & & & & {}_{+}A_3 & & 0/3 & & {}_{+}A_0 & & & & \\
 & & & & \Uparrow & & +0123 & & \uparrow & & & & \\
B_1 & \rightarrow & {}_{+}A_0 & \leftarrow & \partial A_3 & \Leftarrow & {}_{-}\mathbf{A}_3 & \rightarrow & \partial A_1 & \Rightarrow & {}_{+}A_1 & \leftarrow & B_2 \\
\uparrow & & & & \uparrow & & & & \Uparrow & & & & \uparrow \\
{}_{-}\mathbf{A}_0 & & & & {}_{-}\mathbf{A}_0 & & & & {}_{-}\mathbf{A}_1 & & & & {}_{-}\mathbf{A}_1 \\
\downarrow & & & & \downarrow & & & & \downarrow & & & & \downarrow \\
E_3 & \rightarrow & {}_{+}A_0 & \leftarrow & B_2 & & & & E_1 & \rightarrow & {}_{+}A_1 & \leftarrow & B_3
\end{array}
\tag{3b}
$$

The O-X-photons of static Maxwell fields consists of ten sets of components of the vector potential $\{A_\mu, \mu = 0, 1, 2, 3\}$, five are positive and five are negative. Two sets, one positive and one negative, connect the two photons O and X, they are to both photons common. The E_i and B_i and ∂A_μ unity cubes are the same, as for photons of light. In static O-X-photons the $\mu = 3$ oscillator has in both oscillation states the same sign of action: for photons of particles positive and for anti-particle negative action; it characterizes the sign of the charge of the object. The O-X-photons, in which one of the O or X-photons have a $\mu = 3$ oscillator with positive and the other with negative sign, forms photons which interact with pure matter-oscillators (oscillators not carrying action of charges). They can be used to simulate the gravitation. We call them as gravitons, therefore.

The structures of the O-X-photons with wave and particle properties are the same, they are distinguished only by different correlation directions and by different signs of currents. This will be shown at the example of the correlation structure of O-X-photons of static Maxwell fields of negative charges. For saving space only the central part of the structures in following is represented; the whole structures can be obtained at the example of the structure (3). In following the two oscillation states of the O-X-photons of a negative charge is displayed:

Static O-X- photon $(-)0123$ of negative charge with particle properties

$$
\begin{array}{cccccccccccccccccc}
 & & -\mathbf{A}_1 & & & & -A_0 & & & & & -A_2 & & & & -A_3 & & \\
 & & \downarrow & & & & \Downarrow & & & & & \Downarrow & & & & \downarrow & & \\
+A_1 & \leftarrow & \partial A_2 & \Leftarrow & -\mathbf{A}_2 & \rightarrow & \partial A_0 & \Rightarrow & +\mathbf{A}_0 & +\mathbf{A}_2 & \Leftarrow & \partial A_2 & \leftarrow & -\mathbf{A}_0 & \Rightarrow & \partial A_0 & \rightarrow & +\mathbf{A}_3 \\
 & & \Downarrow & & OZ1 & & \downarrow & & & & & \downarrow & & OZ1 & & \Downarrow & & \\
 & & +A_2 & & 1/2 & & +A_1 & & & & & +\mathbf{A}_3 & & 0/3 & & +A_0 & & \\
 & & \uparrow & & -0123 & & \Uparrow & & & & & \Uparrow & & -0123 & & \uparrow & & \\
+A_3 & \Leftarrow & \partial A_3 & \leftarrow & -\mathbf{A}_1 & \Rightarrow & \partial A_1 & \rightarrow & +A_2 & +A_0 & \leftarrow & \partial A_3 & \Leftarrow & -A_3 & \rightarrow & \partial A_1 & \Rightarrow & +\mathbf{A}_1 \\
 & & \Uparrow & & & & \uparrow & & & & & \uparrow & & & & \Uparrow & & \\
 & & -\mathbf{A}_3 & & & & -\mathbf{A}_2 & & & & & -\mathbf{A}_0 & & & & -A_1 & & \\
 & & +\mathbf{A}_1 & & & & +A_0 & & & & & +A_2 & & & & +A_3 & & \\
 & & \uparrow & & & & \Uparrow & & & & & \Uparrow & & & & \uparrow & & \\
-A_1 & \rightarrow & \partial A_2 & \Rightarrow & +\mathbf{A}_2 & \leftarrow & \partial A_0 & \Leftarrow & -\mathbf{A}_0 & -\mathbf{A}_2 & \Rightarrow & \partial A_2 & \rightarrow & +\mathbf{A}_0 & \Leftarrow & \partial A_0 & \leftarrow & -\mathbf{A}_3 \\
 & & \Uparrow & & XZ1 & & \uparrow & & & & & \uparrow & & XZ1 & & \Uparrow & & \\
 & & -A_2 & & 1/2 & & -A_1 & & & & & -\mathbf{A}_3 & & 0/3 & & -A_0 & & \\
 & & \downarrow & & -0123 & & \Downarrow & & & & & \Downarrow & & -0123 & & \downarrow & & \\
-A_3 & \Rightarrow & \partial A_3 & \rightarrow & +\mathbf{A}_1 & \Leftarrow & \partial A_1 & \leftarrow & -A_2 & -A_0 & \rightarrow & \partial A_3 & \Rightarrow & +A_3 & \leftarrow & \partial A_1 & \Leftarrow & -\mathbf{A}_1 \\
 & & \Downarrow & & & & \downarrow & & & & & \downarrow & & & & \Downarrow & & \\
 & & +\mathbf{A}_3 & & & & +\mathbf{A}_2 & & & & & +\mathbf{A}_0 & & & & +A_1 & &
\end{array}
$$

(3a)

$$
\begin{array}{cccccccccccccccccc}
 & & +\mathbf{A}_1 & & & & +\mathbf{A}_0 & & & & & +A_2 & & & & +A_3 & & \\
 & & \uparrow & & & & \Uparrow & & & & & \Uparrow & & & & \uparrow & & \\
-A_1 & \rightarrow & \partial A_2 & \Rightarrow & +\mathbf{A}_2 & \leftarrow & \partial A_0 & \Leftarrow & -A_0 & -\mathbf{A}_2 & \Rightarrow & \partial A_2 & \rightarrow & +A_0 & \Leftarrow & \partial A_0 & \leftarrow & -\mathbf{A}_3 \\
 & & \Uparrow & & OZ2 & & \uparrow & & & & & \uparrow & & OZ2 & & \Uparrow & & \\
 & & -A_2 & & 1/2 & & -A_1 & & & & & -\mathbf{A}_3 & & 0/3 & & -\mathbf{A}_0 & & \\
 & & \downarrow & & -0123 & & \Downarrow & & & & & \Downarrow & & -0123 & & \downarrow & & \\
-A_3 & \Rightarrow & \partial A_3 & \rightarrow & +\mathbf{A}_1 & \Leftarrow & \partial A_1 & \leftarrow & -A_2 & -\mathbf{A}_0 & \rightarrow & \partial A_3 & \Rightarrow & +A_3 & \leftarrow & \partial A_1 & \Leftarrow & -\mathbf{A}_1 \\
 & & \Downarrow & & & & \downarrow & & & & & \downarrow & & & & \Downarrow & & \\
 & & +\mathbf{A}_3 & & & & +\mathbf{A}_2 & & & & & +A_0 & & & & +A_1 & & \\
 & & -\mathbf{A}_1 & & & & -\mathbf{A}_0 & & & & & -A_2 & & & & -A_3 & & \\
 & & \downarrow & & & & \Downarrow & & & & & \Downarrow & & & & \downarrow & & \\
+A_1 & \leftarrow & \partial A_2 & \Leftarrow & -\mathbf{A}_2 & \rightarrow & \partial A_0 & \Rightarrow & +A_0 & +\mathbf{A}_2 & \Leftarrow & \partial A_2 & \leftarrow & -A_0 & \Rightarrow & \partial A_0 & \rightarrow & +\mathbf{A}_3 \\
 & & \Downarrow & & XZ2 & & \downarrow & & & & & \downarrow & & XZ2 & & \Downarrow & & \\
 & & +A_2 & & 1/2 & & +A_1 & & & & & +\mathbf{A}_3 & & 0/3 & & +\mathbf{A}_0 & & \\
 & & \uparrow & & -0123 & & \Uparrow & & & & & \Uparrow & & -0123 & & \uparrow & & \\
+A_3 & \Leftarrow & \partial A_3 & \leftarrow & -\mathbf{A}_1 & \Rightarrow & \partial A_1 & \rightarrow & +A_2 & +\mathbf{A}_0 & \leftarrow & \partial A_3 & \Leftarrow & -A_3 & \rightarrow & \partial A_1 & \Rightarrow & +\mathbf{A}_1 \\
 & & \Uparrow & & & & \uparrow & & & & & \uparrow & & & & \Uparrow & & \\
 & & -\mathbf{A}_3 & & & & -\mathbf{A}_2 & & & & & -A_0 & & & & -A_1 & &
\end{array}
$$

(3b)

For an interpretation of the O-X-photon of a negative charge the two parts (1/2) and (0/3) of the O-X-photon must be overlapped and, because the two photons O and X have common a negative and a positive set of components of the vector potential $\{A_\mu, \mu = 0,1,2,3\}$, the two photons O and X must be in addition superimposed. The positive and negative set of components of the vector potential form the central part of the O-X-photon.

The currents in the correlation structure are interpreted similar as for photons of light. This leads for the oscillation state Z1 in (3a) to following results: The two longitudinal oscillators leads to currents generating positive action and the currents in state Z2 of (3b) to currents with negative action. The two transversal oscillators have currents with different current sign and different circulation directions in both states Z1 and Z2, but they are overlapped by currents with different current signs and the same circulation direction and are cancelled: these currents are annihilating each other; the transversal oscillators are deleted by an overlap with spin correlations. The currents in the longitudinal oscillators of oscillation state Z2 are also overlapped by currents with opposite signs and are also annihilated. The O-X-photons of negative charge with particle properties are only activated with real action in oscillation state Z1 in longitudinal oscillators $\mu = 3$ with negative action and $\mu = 0$ with positive action. If we overlap the two oscillation states, simulating interference, the properties of the oscillation state Z1 determine the properties of the O-X-photon.

The O-X-photon of positive charge, characterized by a positive sign in the $\mu = 3$ oscillator, can be analysed in the same way and leads to the following results: The oscillation state Z1 is completely deactivated, similar as state Z2 of the anti-particle of negative charge and the state Z2 is active in the longitudinal oscillators with $\mu = 3$ with positive action and $\mu = 0$ with negative action ($\mu = 0$: OZ1 $(1/2)/(0/3) = (-+)/(+-)$, XZ1: $(+-)/(-+)$, $\mu = 3$: OZ1:$(1/2) = (++)$, XZ1: $(1/2)$: $(--)$), while the transversal oscillators are deleted, similar as in the anti-particle. The two analysed O-X-photons of negative and positive charges are only active in one oscillation state, they are not able to interfere and have particle properties, therefore.

4 Wave Properties of Static Maxwell Fields

For the formation of wave properties of static Maxwell fields the following combination of oscillation states are constructed:

$$\begin{array}{ll} \mathrm{W1}_\alpha = \mathrm{OZ1}(-)\&\mathrm{XZ1}(+), & \mathrm{W2}_\alpha = \mathrm{OZ2}(-)\&\mathrm{XZ2}(+) \\ \mathrm{W1}_\beta = \mathrm{OZ1}(+)\&\mathrm{XZ1}(-), & \mathrm{W2}_\beta = \mathrm{OZ2}(+)\&\mathrm{XZ2}(-) \end{array}$$

In following the two oscillation states $\mathrm{W1}_\alpha$ and $\mathrm{W2}_\alpha$ are analysed.

State $\mathrm{W1}_\alpha = \mathrm{OZ1}(-)\&\mathrm{XZ1}(+)$

$$\begin{array}{ccccccccccccccccc}
 & & {}_{-}A_1 & & & & {}_{-}A_0 & & & & & {}_{-}\mathbf{A}_2 & & & & {}_{-}A_3 & & \\
 & & \downarrow & & & & \Downarrow & & & & & \Downarrow & & & & \downarrow & & \\
{}_{+}\mathbf{A}_1 & \leftarrow & \partial A_2 & \Rightarrow & {}_{+}\mathbf{A}_2 & \leftarrow & \partial A_0 & \Rightarrow & {}_{+}\mathbf{A}_0 & {}_{+}A_2 & \Leftarrow & \partial A_2 & \leftarrow & {}_{-}\mathbf{A}_0 & \Rightarrow & \partial A_0 & \rightarrow & {}_{+}\mathbf{A}_3 \\
 & & \Uparrow & & OZ1 & & \uparrow & & & & & \downarrow & & OZ1 & & \Downarrow & & \\
 & & {}_{-}A_2 & & 1/2 & & {}_{-}A_1 & & & & & {}_{+}\mathbf{A}_3 & & 0/3 & & {}_{+}A_0 & & \\
 & & \downarrow & & -03 & & \Downarrow & & & & & \Uparrow & & -03 & & \uparrow & & \\
{}_{+}A_3 & \Leftarrow & \partial A_3 & \rightarrow & {}_{+}\mathbf{A}_1 & \Leftarrow & \partial A_1 & \rightarrow & {}_{+}\mathbf{A}_2 & {}_{-}\mathbf{A}_0 & \rightarrow & \partial A_3 & \Leftarrow & {}_{-}A_3 & \rightarrow & \partial A_1 & \Rightarrow & {}_{+}A_1 \\
 & & \Uparrow & & & & \uparrow & & & & & \downarrow & & & & \Uparrow & & \\
 & & {}_{-}\mathbf{A}_3 & & & & {}_{-}A_2 & & & & & {}_{+}A_0 & & & & {}_{-}\mathbf{A}_1 & &
\end{array}$$

$$
\begin{array}{cccccccccccccccccc}
 & & +A_1 & & & & +A_0 & & & & & +\mathbf{A}_2 & & & & +A_3 & & \\
 & & \uparrow & & & & \Uparrow & & & & & \Uparrow & & & & \uparrow & & \\
-\mathbf{A}_1 & \rightarrow & \partial A_2 & \Leftarrow & -\mathbf{A}_2 & \rightarrow & \partial A_0 & \Leftarrow & -\mathbf{A}_0 & -A_2 & \Rightarrow & \partial A_2 & \rightarrow & +\mathbf{A}_0 & \Leftarrow & \partial A_0 & \leftarrow & -\mathbf{A}_3 \\
 & & \Downarrow & & XZ1 & & \downarrow & & & & & \uparrow & & XZ1 & & \Uparrow & & \\
 & & +A_2 & & 1/2 & & +A_1 & & & & & -A_3 & & 0/3 & & -A_0 & & \\
 & & \uparrow & & +03 & & \Uparrow & & & & & \Downarrow & & +03 & & \downarrow & & \\
-\mathbf{A}_3 & \Rightarrow & \partial A_3 & \leftarrow & -\mathbf{A}_1 & \Rightarrow & \partial A_1 & \leftarrow & -\mathbf{A}_2 & +\mathbf{A}_0 & \leftarrow & \partial A_3 & \Rightarrow & +\mathbf{A}_3 & \leftarrow & \partial A_1 & \Leftarrow & -A_1 \\
 & & \Downarrow & & & & \downarrow & & & & & \uparrow & & & & \Downarrow & & \\
 & & +A_3 & & & & +A_2 & & & & & -A_0 & & & & +\mathbf{A}_1 & &
\end{array}
$$

$\mathrm{W2}_\alpha = \mathrm{OZ2}(-)\mathrm{XZ2}(+)$

$$
\begin{array}{cccccccccccccccccc}
 & & +\mathbf{A}_1 & & & & +\mathbf{A}_0 & & & & & +A_2 & & & & +\mathbf{A}_3 & & \\
 & & \uparrow & & & & \Uparrow & & & & & \Uparrow & & & & \uparrow & & \\
-A_1 & \rightarrow & \partial A_2 & \Leftarrow & -A_2 & \rightarrow & \partial A_0 & \Leftarrow & -A_0 & -\mathbf{A}_2 & \Rightarrow & \partial A_2 & \rightarrow & +A_0 & \Leftarrow & \partial A_0 & \leftarrow & -A_3 \\
 & & \Downarrow & & OZ2 & & \downarrow & & & & & \uparrow & & OZ2 & & \Uparrow & & \\
 & & +\mathbf{A}_2 & & 1/2 & & +\mathbf{A}_1 & & & & & -\mathbf{A}_3 & & 0/3 & & -\mathbf{A}_0 & & \\
 & & \uparrow & & -03 & & \Uparrow & & & & & \Downarrow & & -03 & & \downarrow & & \\
-A_3 & \Rightarrow & \partial A_3 & \leftarrow & -A_1 & \Rightarrow & \partial A_1 & \leftarrow & -A_2 & +A_0 & \leftarrow & \partial A_3 & \Rightarrow & +A_3 & \leftarrow & \partial A_1 & \Leftarrow & -\mathbf{A}_1 \\
 & & \Downarrow & & & & \downarrow & & & & & \uparrow & & & & \Downarrow & & \\
 & & +\mathbf{A}_3 & & & & +\mathbf{A}_2 & & & & & -\mathbf{A}_0 & & & & +A_1 & &
\end{array}
$$

$$
\begin{array}{cccccccccccccccccc}
 & & -\mathbf{A}_1 & & & & -\mathbf{A}_0 & & & & & -A_2 & & & & -\mathbf{A}_3 & & \\
 & & \downarrow & & & & \Downarrow & & & & & \Downarrow & & & & \downarrow & & \\
+A_1 & \leftarrow & \partial A_2 & \Rightarrow & +A_2 & \leftarrow & \partial A_0 & \Rightarrow & +A_0 & +\mathbf{A}_2 & \Leftarrow & \partial A_2 & \leftarrow & -A_0 & \Rightarrow & \partial A_0 & \rightarrow & +A_3 \\
 & & \Uparrow & & XZ2 & & \uparrow & & & & & \downarrow & & XZ2 & & \Downarrow & & \\
 & & -\mathbf{A}_2 & & 1/2 & & -\mathbf{A}_1 & & & & & +A_3 & & 0/3 & & +\mathbf{A}_0 & & \\
 & & \downarrow & & +03 & & \Downarrow & & & & & \Uparrow & & +03 & & \uparrow & & \\
+\mathbf{A}_3 & \Leftarrow & \partial A_3 & \rightarrow & +A_1 & \Leftarrow & \partial A_1 & \rightarrow & +A_2 & -A_0 & \rightarrow & \partial A_3 & \Leftarrow & -\mathbf{A}_3 & \rightarrow & \partial A_1 & \Rightarrow & +\mathbf{A}_1 \\
 & & \Uparrow & & & & \uparrow & & & & & \downarrow & & & & \Uparrow & & \\
 & & -A_3 & & & & -\mathbf{A}_2 & & & & & +\mathbf{A}_0 & & & & -A_1 & &
\end{array}
$$

(4)

O and X photons of different signs of action and the same oscillation states are combined. The transversal oscillators have currents with the same circulation direction and different signs of currents: the action of this oscillators is in each photons O and X deactivated. Similar as in static photons with particle properties the two photons O and X have opposite circulation of currents, they are not interacting between each other. The $\mu = 3$ oscillators have in both oscillation states $\mathrm{W1}_\alpha$ and $\mathrm{W2}_\alpha$ different signs in O and X, their resulting action is zero: the sign of charge of static O-X-photons with wave properties is annihilated. Only the $\mu = 0$ oscillator is active in both oscillation states and of opposite sign. If the two oscillation states overlap, simulating the interference, the action of both oscillators is annihilated. The photons $\mathrm{W1}_\alpha$ and $\mathrm{W2}_\alpha$ have wave properties. Similar results are obtained for the for the photons $\mathrm{W1}_\beta$ and $\mathrm{W2}_\beta$. Wave properties are formed in generating both kinds of static photons $\mathrm{W1}_\alpha/\mathrm{W2}_\alpha$ and $\mathrm{W1}_\beta/\mathrm{W2}_\beta$ with wave properties. The different signs of the photons O or X in the states $\mathrm{W1}_\alpha$ and $\mathrm{W1}_\beta$ and similar in $\mathrm{W2}_\alpha$ and $\mathrm{W2}_\beta$ contribute to the stabilization of wave properties. If in one of the photons O or X in one state α receive a change of action, which is added or subtracted, the other of the O or X photons receive the same change of action in the state β, which will be subtracted or added, respectively.

Similar to photons of light the O-X-photons of static Maxwell fields propagate in vacuum by induction, forming during one oscillation state, for example during formation of the state W1 the state W2. The state W2 is generated in front of W1 by a correlation structure, in which the currents are formed under conditions of the PSCO. In the following oscillation state from state W2 is forming the state W1, which currents have the same directions as the currents of the original state W1, but, due to the oscillation of the $\mu = 0$ oscillator, with action of opposite sign. This is demonstrated in fig.3, which show two oscillation states of a positive charge at the example of the two unity cubes ∂A_0 and ∂A_2. Overlapping two oscillation states generated by induction, the currents of different states have the same circulation direction and different current signs; they interfere destructive, which is a prove of wave properties.

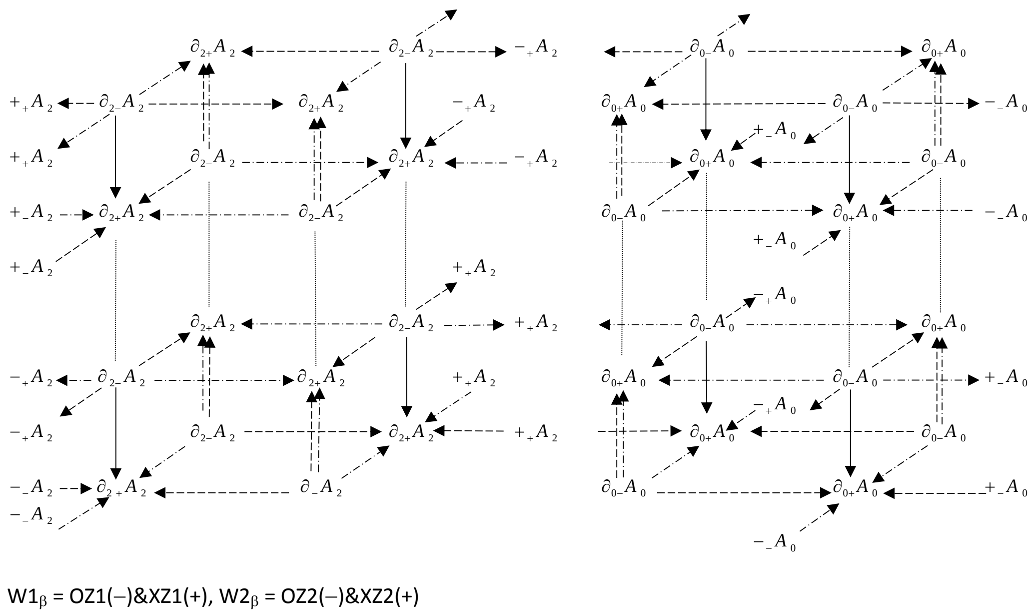

Figure 3: Progress of a wave of a static Maxwell photon of a positive charge by induction, from state W1 (down) to state W2 (above) at the example of the two unity cubes ∂A_0 and ∂A_2. During change of state the currents flow always simultaneously from the creator plane to the annihilator plane. For the propagation of a wave of static photons the contribution of the Maxwell vacuum is needed.

5 Wave and Particle Properties of Scalar Oscillators

The O-X- photons of static Maxwell fields interact with the oscillators of the core of the objects. In our formalism the core of objects consists of a large number of oscillators. The oscillators are described by scalar fields. We developed the scalar oscillators in two steps by forming fist scalar oscillators from the scalar Lagrange density and from covariant four dimensional scalar commutators of communication relations of quantum mechanics. The two scalar commutators of communication relations in each scalar oscillators have the same wave properties, as the four dimensional commutators in the static photons O and X. We call them also O and X photons, therefore. The properties of the static O-X-photons (their current signs and current direction) are introduced in the next step into the scalar oscillators on the positions of the scalar currents of absorbed O and X photons. For the $\mu = 0$ oscillator in particle properties and for the two scalar oscillators O1 and O2 of an anti-particle, oscillating in two oscillation states the structures are:

$\mu =$ 0 oscillator, state Z1(1), particle properties:

$$
\begin{array}{cccccc|cccccc}
\multicolumn{3}{l}{\text{O1: Z1-LS}} & \multicolumn{3}{l|}{\text{RS}} & \multicolumn{3}{l}{\text{O2: Z1-LS}} & \multicolumn{3}{l}{\text{RS}} \\
{}_{-}\Phi & \Leftarrow - & {}_{+}\varphi^{\dagger} & {}_{+}\Phi^{\dagger} & + \Rightarrow & {}_{+}\varphi & {}_{-}\varphi^{\dagger} & - \Rightarrow & {}_{+}\Phi & {}_{+}\varphi & \Leftarrow + & {}_{+}\Phi^{\dagger} \\
\uparrow & \mu 1 & \downarrow & \downarrow & \mu 1 & \uparrow & \downarrow & \mu 1 & \uparrow & \uparrow & \mu 1 & \downarrow \\
{}_{+}\varphi^{\dagger} & - \Rightarrow & {}_{+}\Phi & {}_{+}\varphi & \Leftarrow + & {}_{-}\Phi^{\dagger} & {}_{+}\Phi & \Leftarrow - & {}_{+}\varphi^{\dagger} & {}_{+}\Phi^{\dagger} & + \Rightarrow & {}_{-}\varphi \\
\mathbf{G} & X(1/2) & & & X(0/3) & & \mathbf{E} & X(1/2) & & & X(0/3) & \\
{}_{-}\varphi & \Leftarrow + & {}_{-}\Phi^{\dagger} & {}_{-}\varphi^{\dagger} & - \Rightarrow & {}_{+}\Phi & {}_{-}\Phi^{\dagger} & + \Rightarrow & {}_{-}\varphi & {}_{-}\Phi & \Leftarrow - & {}_{+}\varphi^{\dagger} \\
\uparrow & \mu 2 & \downarrow & \downarrow & \mu 2 & \uparrow & \downarrow & \mu 2 & \uparrow & \uparrow & \mu 2 & \downarrow \\
{}_{+}\Phi & + \Rightarrow & {}_{-}\varphi & {}_{-}\Phi & \Leftarrow - & {}_{-}\varphi^{\dagger} & {}_{+}\varphi & \Leftarrow + & {}_{-}\Phi^{\dagger} & {}_{-}\varphi^{\dagger} & - \Rightarrow & {}_{-}\Phi \\
\text{o } \mathbf{B} & \mathrm{O}(1/2) & & & \mathrm{O}(0/3) & & \mathbf{D} & \mathrm{O}(1/2) & & & \mathrm{O}(0/3) & \\
\multicolumn{6}{l|}{\text{Z1(1)} = \text{O}(-)\text{-X}(+)} & \multicolumn{6}{l}{\text{Z1(1)} = \text{O}(+)\text{-X}(-)}
\end{array}
$$

$\mu = 0$ oscillator, state Z2(1):

$$
\begin{array}{cccccc|cccccc}
\multicolumn{3}{l}{\text{O1: Z2-LS}} & \multicolumn{3}{l|}{\text{RS}} & \multicolumn{3}{l}{\text{O2: Z2-LS}} & \multicolumn{3}{l}{\text{RS}} \\
{}_{-}\varphi^{\dagger} & - \Rightarrow & {}_{+}\Phi & {}_{+}\varphi & \Leftarrow + & {}_{+}\Phi^{\dagger} & {}_{-}\Phi & \Leftarrow - & {}_{+}\varphi^{\dagger} & {}_{+}\Phi^{\dagger} & + \Rightarrow & {}_{+}\varphi \\
\downarrow & \mu 1 & \uparrow & \uparrow & \mu 1 & \downarrow & \uparrow & \mu 1 & \downarrow & \downarrow & \mu 1 & \uparrow \\
{}_{+}\Phi & \Leftarrow - & {}_{+}\varphi^{\dagger} & {}_{+}\Phi^{\dagger} & + \Rightarrow & {}_{-}\varphi & {}_{+}\varphi^{\dagger} & - \Rightarrow & {}_{+}\Phi & {}_{+}\varphi & \Leftarrow + & {}_{-}\Phi^{\dagger} \\
\mathbf{G} & X(1/2) & & & X(0/3) & & \mathbf{E} & X(1/2) & & & X(0/3) & \\
{}_{-}\Phi^{\dagger} & + \Rightarrow & {}_{-}\varphi & {}_{-}\Phi & \Leftarrow - & {}_{+}\varphi^{\dagger} & {}_{-}\varphi & \Leftarrow + & {}_{-}\Phi^{\dagger} & {}_{-}\varphi^{\dagger} & - \Rightarrow & {}_{+}\Phi \\
\downarrow & \mu 2 & \uparrow & \uparrow & \mu 2 & \downarrow & \uparrow & \mu 2 & \downarrow & \downarrow & \mu 2 & \uparrow \\
{}_{+}\varphi & \Leftarrow + & {}_{-}\Phi^{\dagger} & {}_{-}\varphi^{\dagger} & - \Rightarrow & {}_{-}\Phi & {}_{+}\Phi & + \Rightarrow & {}_{-}\varphi & {}_{-}\Phi & \Leftarrow - & {}_{-}\varphi^{\dagger} \\
\text{o } \mathbf{B} & \mathrm{O}(1/2) & & & \mathrm{O}(0/3) & & \mathbf{D} & \mathrm{O}(1/2) & & & \mathrm{O}(0/3) & \\
\multicolumn{6}{l|}{\text{Z2(1)} = \text{O}(+)\text{-X}(-)} & \multicolumn{6}{l}{\text{Z2(1)} = \text{O}(-)\text{-X}(+)}
\end{array}
$$

(5)

The four μ-oscillator have the same structure, the scalar oscillators are covariant. Each scalar oscillator O1 or O2 consists of the two products $\varphi\varphi^{\dagger}$ and $\varphi^{\dagger}\varphi$ and of an O-X-photon. The large letters Φ describe positive and the small letters φ negative scalar components. The O and X photons are described in (5) by their parts (1/2) and (0/3) and the double arrows describe the currents formed by correlations of commutators of communication relations in the static O-X-photons in (4). The arrows describe, similar as in static photons correlations, which are always directed from creator to the annihilator. Two scalar oscillators O1 and O2 are needed for the description of the interaction between the photons of the photon cloud and the oscillators of an elementary object. (5) shows the two oscillation states of the $\mu = 0$ oscillator with the introduced O and X photons.

The interaction between static O-X-photons of the photo cloud and the O and X-photons in scalar oscillator of objects is described by superposition (overlap), similar as the interaction between the photons in photon cloud. The interaction occurs by an overlap of equally directed currents.

In relations (6) the same $\mu = 0$ oscillator with wave properties is depicted:

$\mu = 0$ oscillator, state Z1, anti-particle, wave properties

O1: Z1-LS RS O2: Z1-LS RS

$$\begin{array}{cccccccccccc}
{}_-\Phi & \Leftarrow - & {}_+\varphi^\dagger & {}_+\Phi^\dagger & + \Rightarrow & {}_+\varphi & {}_-\Phi^\dagger & - \Rightarrow & {}_+\varphi & {}_+\Phi & \Leftarrow + & {}_+\varphi^\dagger \\
\uparrow & \mu 1 & \downarrow & \downarrow & \mu 1 & \uparrow & \downarrow & \mu 1 & \uparrow & \uparrow & \mu 1 & \downarrow \\
{}_+\varphi^\dagger & - \Rightarrow & {}_+\Phi & {}_+\varphi & \Leftarrow + & {}_-\Phi^\dagger & {}_+\varphi & \Leftarrow - & {}_+\Phi^\dagger & {}_+\varphi^\dagger & + \Rightarrow & {}_-\Phi \\
 & O(1/2) & & & O(0/3) & & & O(1/2) & & & O(0/3) & \\
{}_-\varphi^\dagger & - \Rightarrow & {}_-\Phi & {}_-\varphi & \Leftarrow + & {}_+\Phi^\dagger & {}_-\varphi & \Leftarrow - & {}_-\Phi^\dagger & {}_-\varphi^\dagger & + \Rightarrow & {}_+\Phi \\
\downarrow & \mu 2 & \uparrow & \uparrow & \mu 2 & \downarrow & \uparrow & \mu 2 & \downarrow & \downarrow & \mu 2 & \uparrow \\
{}_+\Phi & \Leftarrow - & {}_-\varphi^\dagger & {}_-\Phi^\dagger & + \Rightarrow & {}_-\varphi & {}_+\Phi & - \Rightarrow & {}_-\varphi & {}_-\Phi & \Leftarrow + & {}_-\varphi^\dagger \\
\mathrm{o} & \mathrm{X}(1/2)) & & & \mathrm{X}(0/3) & & & \mathrm{X}(1/2) & & & \mathrm{X}(0/3) &
\end{array}$$

B: Z1 = O(+)-X(−) = W1$_\beta$ **A:** Z1 = O(−)-X(+) = W1$_\alpha$

$\mu = 0$ oscillator, state Z2

O1: Z2-LS RS O2: Z2-LS RS

$$\begin{array}{cccccccccccc}
{}_-\varphi^\dagger & - \Rightarrow & {}_+\Phi & {}_+\varphi & \Leftarrow + & {}_+\Phi^\dagger & {}_-\varphi & \Leftarrow - & {}_+\Phi^\dagger & {}_+\varphi^\dagger & + \Rightarrow & {}_+\Phi \\
\downarrow & \mu 1 & \uparrow & \uparrow & \mu 1 & \downarrow & \uparrow & \mu 1 & \downarrow & \downarrow & \mu 1 & \uparrow \\
{}_+\Phi & \Leftarrow - & {}_+\varphi^\dagger & {}_+\Phi^\dagger & + \Rightarrow & {}_-\varphi & {}_+\Phi^\dagger & - \Rightarrow & {}_+\varphi & {}_+\Phi & \Leftarrow + & {}_-\varphi^\dagger \\
 & O(1/2) & & & O(0/3) & & & O(1/2) & & & O(0/3) & \\
{}_-\Phi & \Leftarrow - & {}_-\varphi^\dagger & {}_-\Phi^\dagger & + \Rightarrow & {}_+\varphi & {}_-\Phi^\dagger & - \Rightarrow & {}_-\varphi & {}_-\Phi & \Leftarrow + & {}_+\varphi^\dagger \\
\uparrow & \mu 2 & \downarrow & \downarrow & \mu 2 & \uparrow & \downarrow & \mu 2 & \uparrow & \uparrow & \mu 2 & \downarrow \\
{}_+\varphi & - \Rightarrow & {}_-\Phi & {}_-\varphi & \Leftarrow + & {}_-\Phi^\dagger & {}_+\varphi & \Leftarrow - & {}_-\Phi^\dagger & {}_-\varphi^\dagger & + \Rightarrow & {}_-\Phi \\
\mathrm{o} & \mathrm{X}(1/2) & & & \mathrm{X}(0/3) & & & \mathrm{X}(1/2) & & & \mathrm{X}(0/3) &
\end{array}$$

C: Z2 = O(−)-X(+) = W2$_\beta$ **D:** Z2 = O(+)-X(−) = W2$_\alpha$

(6)

In oscillators O1 or O2 with particle properties the two photons O and X have the same circulation directions in each single photon O and X and different signs of currents. In difference to the scalar oscillators with particle properties in wave properties the oscillators O1 and O2 have in absorbed photons O and X different circulation direction and the same signs of currents.

6 Oscillation and Interaction Mechanism in Wave and Particle Properties of Material Waves

As shown in the representations (6) in wave properties each of the photons W1 and W2 with wave properties can be related to one of the scalar oscillators O1 and O2. In wave properties the photons of static Maxwell fields force the oscillation of the scalar oscillators by a direct relation of each of the photons O and X in photon cloud to the absorbed photons O and X in scalar oscillators.

In particle properties the interaction of an object with a change of action occurs. In the presented model the interaction occurs in the following steps: In the photon cloud an overlap of photons of two different objects with different action occurs. If the two interacting O-X- photons are carrying different action described by a four dimensional delta of action: O-X and O+Δ-X+Δ, the interaction occurs under conditions of action minimization (Principle of Hamilton) according to O-X + O+Δ-X+Δ $\rightarrow$ O+Δ-X + O - X+Δ. As a result of interaction in photon cloud both O-X-photons carry the same action, which is the condition for the third law of Newton. A single O+Δ-X or O - X+Δ photon is interacting with the scalar oscillators O1&O2 by an overlap of parallel and same directed currents. In one interaction process from the O+Δ-X photon the O+Δ photon is superimposed to the absorbed O-photon of scalar oscillator O1 and the X-photon on the absorbed X-photons of oscillator O2. This is possible, because in particle properties the photons O and X have in the scalar oscillators O1 and O2 different circulation directions of currents. In the following interaction process from the O-X+Δ photon the O-photon is superimposed on the O-photon of the scalar oscillator O2 and the X+Δ photon on the X-photon of the oscillator O1. During each oscillation phase in which action after absorption of the delta is different from zero, the object changes its rest frame. After a four times oscillation process all four absorbed O and X photons have changed its action by a delta of action and the object return in a new rest frame.

From the oscillation mechanism in wave and particle properties it is visible, why the scalar oscillators must oscillate with different structures in wave and particle properties. In both kinds of oscillation the photons of the photon cloud force the kind of oscillation on the scalar oscillators. This occurs by an overlap of parallel and the same current circulation in absorbed photons. In wave properties each photon O and X of the photon cloud forces one of the O or X photons in the scalar oscillators with the same circulation direction to the same oscillation mechanism, so that all oscillators in the photon cloud oscillate in the same rhythm as the related photons in the scalar oscillators. There is a common and parallel oscillation of all photons in the photon cloud and in scalar oscillators.

In particle properties the O-X-photons carry a delta of action, this delta must be located in one of the two scalar oscillators with the photons O and X. Starting from a rest frame, where action is zero in the oscillators, the delta of action absorbed in one of the photons O or X in O1 or O2 causes a change of action and the following delta must be absorbed under conditions of action minimization in an another X or O photon with parallel and same directed currents. If the first delta is absorbed in O from O1, the following delta must be absorbed in X of O2. If the next delta is absorbed in X of O1 the following delta will, under conditions of action minimization be absorbed in O of O2. The realisation of action minimization during interaction in particle properties is possible, when, as it is shown in relations (5), the O and X photons will have different circulation directions of currents in each of the two oscillators O1 and O2 and if the circulation direction in O1 and O2 in O-photon is different and similar for the X-photon.

The mechanism of formation of wave properties of a charge in a potential gradient is different to that described in the present paper. In an interaction between a charge and the photons of the gradient, the O-X-photons of the gradient contain in each photon O and X a difference of action in relation to the absorbed O and X photons. During the absorption of the deltas of action by the oscillators, the charge remain in a rest frame. Details are described in [5].

7 Change Between Wave and Particle Properties

In wave properties the elementary object is in a rest frame; the rest frame is characterized by an annihilation of action in photons in the photon cloud and in the scalar oscillators. The photon cloud of objects is only in an interaction with the photons of vacuum, which action is deactivated. Especially the action in the longitudinal oscillators $\mu = 3$ is deleted that is the charge is neutralized. The wave properties turn into particle properties if in the photon cloud the photons interact with photons of different action, generating deltas of action. The deltas with real action are absorbed by the O or X photons of scalar oscillators and force the scalar oscillators from an oscillation in wave in such of particle properties, in which action can be minimized after two times of absorption of a delta of action. The object will operate in particle properties, as long as there is an interaction in the photon cloud. When there is no change of action in the photon cloud, the object return into wave properties under conditions of action minimization: in particle properties real action in the μ =3 oscillators is different from zero, in wave properties real action in the $\mu = 3$ oscillators is reduced to zero (is virtual).

In the mechanism of change between wave and particle properties the change of sign of action in one of the photons O or X must be explained. In formation of wave properties of complex molecules this explanation is easy, because they consist of photons of both charges. This is the reason why complex molecules easy can form wave properties. For single charges, for example for an electron beam, for the two photons O and X with the same sign of action in the $\mu = 3$ oscillator, the following mechanism is proposed: In the photons of the photon cloud the interaction leads to a change of action in one of the photons O and X. This delta of action is in the exchange state real. The delta of action is absorbed in one of the photons O or X in O1 or O2 and generates a change of circulation direction from that of wave into that of particle properties. With the change of circulation direction or with the change of the sign of currents a change of action occur. Changing both signs, the sign of action remain the same. Without of interaction the oscillator returns automatically from particle properties into wave properties under condition of action reduction. Charges in a rest frame without interaction remain always in wave properties with action in the $\mu = 3$ oscillator annihilated.

8 Summary and Discussion

Representing elementary objects as correlation structures with oscillator properties, the wave-particle dualism of light and of material waves can be described causal and local. Photons of light change their wave and particle properties simply by exchanging the signs in their transversal currents. For material waves the wave and particle properties of photons of static Maxwell fields and of the oscillators of the core of the objects and their interaction must be considered. In a combination of static photons of positive and negative charges the photons of static Maxwell fields form wave properties, in which the charge characterized by the μ =3 oscillators is annihilated. The particle and wave properties of the scalar oscillators are determined under conditions of action minimization by the the properties of the wave or particle properties in the photons of the photon cloud. Particle properties results always due to an in-elastic interaction, during which action is changed in photon cloud and absorbed by the scalar oscillators under change of the rest frame. Wave properties are always restored from particle properties in a rest frame under conditions of action minimization.

The wave particle dualism is on correlation space causal and local. The proposed solution to the wave-particle dualism is not appearing on space time. To prove the behaviour in particle and in wave properties experimentally it should be possible to measure in photons of static Maxwell fields and in oscillators of objects the local currents during the oscillation under different conditions with wave and particle properties. This seems at present not possible. The explanation of the wave-particle dualism is physically real, however, because it is part of a general explanation of quantum mechanical effects given by the Physical Information Theory, discussed in [2].

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