The expression $E = h \times f$ is misleading because it implies the distribution of a photon quantum over 299 792 458 m, while the expression $E = (h \times c)/\lambda$ enables us to explain the particle-wave duality

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Abstract: The two equations $E = h \times f$ and $E = (h \times c)/\lambda$ for the quantum of energy of electromagnetic radiation provide the same result but describe electromagnetic radiation very differently. $E = (h \times c)/\lambda$ describes the quantum of energy of electromagnetic radiation to be located already in one wavelength and therefore like a particle. $E = h \times f$ describes the quantum of energy distributed over 299 792 458 m and therefore like a wave. To obtain $h \times f$ for the quantum of energy, we have to refer the quantum of energy to 299 792 458 m. Only then we obtain from $E = (h \times c)/(299\ 792\ 458\ \mathrm{m})$, as the distance of 299 792 458 m of the velocity c is cancelling out now, $E = h \times 1/\mathrm{s} = h \times \mathrm{Hz}$, which is the precondition to obtain the correct value for the quantum of energy by multiplying Planck's constant h by the frequency f. This already indicates the necessity of today's physics to have to speak of a particle-wave duality. It turns out that electromagnetic radiation consists of the first wavelength that carries the quantum of energy and behaves like a particle, which today is called "photon," and a few following wavelengths that do not carry a further quantum of energy and behave like a wave, which today is called "electromagnetic wave." By this knowledge, the particle-wave duality vanishes, and we obtain one single physical phenomenon, which I call "photon-wave." The strange behavior of quantum objects at a single slit, at double-slits, and at beam splitters can now be understood in a causal way. "God does not play dice!" Einstein was right.
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Résumé: Les deux équations $E = h \times f$ et $E = (h \times c)/\lambda$ pour le quantum d'énergie du rayonnement électromagnétique fournissent le même résultat mais décrivent le rayonnement électromagnétique de manière très différente. $E = (h \times c)/\lambda$ décrit le quantum d'énergie du rayonnement électromagnétique se trouvant dans une longueur d'onde et est donc comparable à une particule. $E = h \times f$ décrit le quantum d'énergie distribué sur 299 792 458 m et est donc comparable à une onde. Pour obtenir le résultat de l'équation $h \times f$ pour le quantum d'énergie, nous devons appliquer un quantum d'énergie de 299 792 458 m. Nous obtenons alors à partir de $E = (h \times c)/(299\ 792\ 458\ \mathrm{m})$, étant donné que la distance de 299 792 458 m de la vitesse c réduit les effets, $E = h \times 1/\mathrm{s} = h \times \mathrm{Hz}$, qui est la condition préalable requise pour obtenir la valeur correcte pour le quantum d'énergie en multipliant la constante de Planck par la fréquence f. Cela indique déjà la nécessité pour la physique d'aujourd'hui de parler d'une dualité particule/onde. Il s'avère que le rayonnement électromagnétique est constitué de la première longueur d'onde qui transporte le quantum d'énergie et se comporte comme une particule, ce que l'on appelle aujourd'hui un photon, et de quelques autres longueurs d'onde suivantes qui ne transportent pas d'autre quantum d'énergie et se comportent comme une onde, ce que l'on appelle aujourd'hui l'onde électromagnétique. Cette connaissance fait disparaître la dualité particule/onde et nous n'obtenons qu'un seul phénomène physique, que j'appelle un photon onde. Le comportement étrange des objets quantiques au niveau des fentes simples et doubles et des séparateurs de faisceaux peut désormais être compris de manière causale. "Dieu ne joue pas aux dés!". Einstein avait raison.

Key words: Planck Constant; Planck's Quantum of Action; Quantum of Energy; Particle-Wave Duality; Electromagnetic Wave; Copenhagen Interpretation; Quantum Entanglement; Binary Quantum Model; Single-Slit and Double-Slit Experiments; Interference Experiments.

I. INTRODUCTION

Equation $E = h \times f$ is misleading, because it defines the quantum of energy of photons, as if distributing over 299 792 458 m. Instead, we have to use equation $E = q_E/\lambda$ ($q_E = h \times c$) for the quantum of energy of a photon, which provides the same result. The natural constant q_E refers the quantum of energy of electromagnetic radiation to only one single wavelength. According to that, the first wavelength carries the quantum of energy and therefore must have

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different properties than the following wavelengths that cannot carry a further quantum of energy. The first wavelength that carries the quantum energy can be defined as a particle, which I call photon and following wavelengths that cannot carry a further quantum energy can be defined as a wave, which I call electromagnetic wave. In this case, the particle-wave duality vanishes, and we obtain one single physical phenomenon, which I call photon-wave. The electromagnetic wave behind the photon is a "hidden variable" that can be separated from the photon and interfere with the photon at experiments with double-slits and similar experiments, while only the photon, which carries the quantum of energy, can cause an interference pattern.

II. THE DIFFERENCES BETWEEN THE TWO EQUATIONS FOR THE QUANTUM OF ENERGY OF ELECTROMAGNETIC RADIATION AND THE CONSEQUENCES THAT RESULT FROM THEM

Everybody knows the fundamental equation of quantum physics for the quantum of energy of electromagnetic radiation, where h is the Planck constant and f is the frequency

$$E_{\text{ph}} = h \times f. \tag{1}$$

In Eq. (1), the Planck constant h does not refer to wavelengths, which must contain the quantum of energy.

A natural constant that describes the quantum energy of electromagnetic radiation with respect to wavelengths we can derive from the following equation:

$$\begin{aligned} c &= \lambda \times f, \\ f &= \frac{c}{\lambda}. \end{aligned} \tag{2}$$

Inserting the result of Eq. (2) in Eq. (1), we obtain

$$\begin{aligned} E_{\text{ph}} &= h \times f, \\ E_{\text{ph}} &= \frac{h \times c}{\lambda}, \\ E_{\text{ph}} &= \frac{q_E}{\lambda}, \end{aligned} \tag{3}$$

where q_{E} is the natural constant I define for the quantum of energy per wavelength, which has the value

$$\begin{aligned} q_E &= h \times c = 6.626 \times 10^{-34}\,\text{J s} \times 299\,792\,458\,\frac{\text{m}}{\text{s}}, \\ q_E &= 1.986\,445\,857 \times 10^{-25}\,\text{J m}. \end{aligned} \tag{4}$$

Physicists use two equations for calculating the quantum of energy of electromagnetic radiation, which we call either photon or electromagnetic wave today

$$h \times f = \frac{h \times c}{\lambda}. \tag{5}$$

From both equations, we get the same correct value for the quantum of energy of a photon, respectively, for an electromagnetic wave with a certain frequency, respectively, a certain wavelength. In a quantitative sense, both equations are equivalent, but in a qualitative sense, they are very different that's why we have to examine both equations more thoroughly. The term on the right side of Eq. (5) is immediately understandable. Considering that a photon is some kind of object that moves, it must be defined by a certain velocity, represented by the velocity c, by a certain largeness of the object, which is represented by the wavelength, and by some kind of structure for which Planck's constant h remains, which must represent this structure. The term $h \times f$ on the left side of Eq. (5) that is usually used for calculating the quantum of energy of a photon is not immediately understandable. The term on the left side of Eq. (5) can be derived from the term on the right side of Eq. (5). Instead of referring the energy to one wavelength, we can refer the energy of a photon to any distance, which has nothing to with the real size of the photon represented by its wavelength. Let us take, for example, a distance of 1000 m

$$\frac{h \times c}{\lambda} \rightarrow \frac{h \times c}{1000\,\text{m}}. \tag{6}$$

Using a wavelength of $2.997\ 924\ 58 \times 10^{-7}$ m, we obtain in this case for the quantum of energy of the photon, as it is now distributed over 1000 m and therefore distributed over a distance of 3 335 640 952 wavelengths, a value for the quantum of energy per wavelength that is 3 335 640 952 times less than before distributing the energy

$$\begin{aligned} \frac{h \times c}{\dfrac{1000\,\text{m} \times \lambda}{\lambda}} &= \frac{h \times c}{\dfrac{1000\,\text{m}}{2.997\,924\,58 \times 10^{-7}\,\text{m}} \times \lambda} \\ &= \frac{h \times c}{3\,335\,640\,952 \times \lambda}. \end{aligned} \tag{7}$$

As this is the wrong value for the quantum of energy of the photon, we have to multiply this term by 3 335 640 952, which corresponds with the number of wavelengths that are thought to be spread over 1000 m and therefore contain less energy per wavelength, to obtain the correct result for the quantum of energy, which is identical with the quantum of energy (q_{E}) per wavelength, which means that the quantum of energy must already be included in the first wavelength

$$E = \frac{3\,335\,640\,952 \times h \times c}{3\,335\,640\,952 \times \lambda} = \frac{h \times c}{\lambda} = \frac{q_E}{\lambda}. \tag{8}$$

Instead of referring the quantum of energy of a photon to 1000 m, we can also refer the quantum of energy to the distance of 299 792 458 m, which has nothing to with the real size of the photon represented by its wavelength

$$\frac{h \times c}{\lambda} \rightarrow \frac{h \times c}{299\,792\,458\,\text{m}}. \tag{9}$$

Using a wavelength of $2.997\ 924\ 58 \times 10^{-7}$ m, we obtain in this case for the quantum energy of the photon, as it is now distributed over 299 792 458 m and therefore distributed over 1×10^{15} wavelengths, a value for the quantum of energy per wavelength that is 1×10^{15} times less than before distributing the energy over 299 792 458 m

$$\frac{\frac{h\times c}{299\,792\,458\,\mathrm{m}\times\lambda}}{\lambda}=\frac{h\times c}{\frac{299\,792\,458\,\mathrm{m}}{2.997\,924\,58\times10^{-7}\,\mathrm{m}}\times\lambda}=\frac{h\times c}{1\times10^{15}\times\lambda}. \tag{10}$$

As this is the wrong value for the quantum of energy of the photon, we have to multiply this term by 1×10^{15}, which corresponds with the number of wavelengths that are thought to be spread over 299 792 458 m and therefore contain less energy than the real single wavelength to obtain the correct result

$$\begin{aligned}
E&=\frac{1\times10^{15}\times h\times c}{1\times10^{15}\times\lambda}=\frac{h\times c}{\lambda}=\lambda,\\
E&=\frac{1\times10^{15}\times h\times c}{1\times10^{15}\times\lambda}=1\times10^{15}\times h\times\frac{c}{1\times10^{15}\times\lambda},\\
E&=1\times10^{15}\times h\\
&\quad\times\frac{299\,792\,458\,\frac{\mathrm{m}}{\mathrm{s}}}{1\times10^{15}\times2.997\,924\,58\times10^{-7}\,\mathrm{m}}=1\times10^{15}\\
&\quad\times h\times\frac{1\times10^{15}}{1\times10^{15}\,\mathrm{s}},\\
E&=1\times10^{15}\times h\times\frac{1}{\mathrm{s}}=h\times f.
\end{aligned} \tag{11}$$

Equations (10) and (11) prove that the term $h\times f$ distributes the quantum of energy of one real wavelength of a photon on a number of fictional wavelengths that fit into the distance of 299 792 458 m. Instead of calculating the quantum of energy by Eqs. (10) and (11), we could have directly used Eq. (9), which artificially distributes the quantum of energy over 1×10^{15} wavelengths that fit into the distance of 299 792 458 m

$$\begin{aligned}
&\frac{h\times c}{\lambda}\rightarrow\frac{h\times c}{299\,792\,458\,\mathrm{m}}\\
&\frac{h\times299\,792\,458\,\frac{\mathrm{m}}{\mathrm{s}}}{299\,792\,458\,\mathrm{m}}=h\times\frac{1}{\mathrm{s}}<\frac{h\times c}{\lambda}\rightarrow1\times10^{15}\\
&\quad\times h\times\frac{1}{\mathrm{s}}=h\times f=\frac{h\times c}{\lambda}=\frac{q_E}{\lambda}.
\end{aligned} \tag{12}$$

Referring the quantum of energy to the distance of 299 792 458 m is just a mathematical "trick" to obtain the unit Hz = 1/s, which is the unit of frequency, at the price that the wavelength λ of the photon is stretched to many fictitious wavelengths that altogether measure 299 792 458 m, as if the photon was 299 792 458 m long. Of course, this means that the energy of the photon in relation to one wavelength λ is now much smaller, which has to be compensated by multiplying $h\times1/\mathrm{s}$ by the number of wavelengths that fit into the distance of 299 792 458 m, which corresponds with the value of the frequency. Stretching the size of the photon from one wavelength to many fictitious wavelengths that fit in 299 792 458 m and multiplying the value, we obtained by the frequency is just a mathematical method to obtain a simple equation for calculating the correct quantitative value for the quantum of energy of electromagnetic radiation. Physicists are used to equation $E=h\times f$, but it qualitatively describes a photon in an unrealistic way. According to equation $E=(h\times c)/\lambda$, the quantum of energy must be already contained in one single wavelength. Therefore, in a qualitative sense, the terms $h\times f$ and $(h\times c)/\lambda$ are not equivalent. The term $h\times f$ is artificial and veils the real physical characteristics of electromagnetic radiation, while the term $(h\times c)/\lambda$ enables us to better understand the properties of electromagnetic radiation. Both terms are correct in quantitative terms, while only the term $(h\times c)/\lambda$ is correct in qualitative terms.

The scientist Cameron Rebigsol, one of the speakers of the international conference "Physics beyond relativity" in October 2019 in Prague,[1] measured about 97 wavelengths in an empirical experiment for an electromagnetic wave with the frequency of 1×10^{15} Hz, which he published in his article "Third evidence of an Aether" (pp. 20–25).[2] With his measurements and his finding that there is a contradiction in terms of the real length of a photon and the calculation of the quantum of energy, according to today's quantum physics, Cameron Rebigsol stimulated my considerations. Physicists who wrongly think that the term $h\times f$ depicts the real physical characteristics of electromagnetic radiation and that the waves are evenly distributed over 299 792 458 m will argue that 97 cycles represent only a fraction and not the whole electromagnetic wave (photon). But the electromagnetic wave (photon) is much shorter than 299 792 458 m, and it is not possible that one wavelength can contain the quantum of energy because of equation $E=(h\times c)/\lambda$, while 97 wavelengths (cycles) shall be a fraction of the wavelength in this equation.

According to the natural constant q_E $(=h\times c)$, the quantum of energy of a photon must be distributed only over one single wavelength, and we obtain for the quantum of energy E_{ph}

$$\begin{aligned}
E_{\mathrm{ph}}&=\frac{q_E}{\lambda},\\
E_{\mathrm{ph}}&=\frac{1.986\,445\,857\times10^{-25}\,\mathrm{J\,m}}{\lambda},\\
E_{\mathrm{ph}}&=\frac{1.986\,445\,857\times10^{-25}\,\mathrm{J\,m}}{2.997\,924\,58\times10^{-7}\,\mathrm{m}}=6.626\times10^{-19}\,\mathrm{J}.
\end{aligned} \tag{13}$$

The same value can be calculated by the mathematically artificial equation used today, if we insert the frequency of 1×10^{15} Hz in Eq. (1)

$$\begin{aligned}
E_{\mathrm{ph}}&=h\times f=h\times\text{cycles},\\
E_{\mathrm{ph}}&=6.626\times10^{-34}\,\mathrm{J\,s}\times1\times10^{15}\\
\mathrm{Hz}&=6.626\times10^{-19}\,\mathrm{J}.
\end{aligned} \tag{14}$$

For the quantum of energy E_{q} of a photon per cycle, we obtain a different value than the value given by Eqs. (5) and (6)

$$E_{\mathrm{q}}=\frac{E_{\mathrm{ph}}}{\text{cycles}}=\frac{h\times 1\times 10^{15}\,\mathrm{Hz}}{1\times 10^{15}\times \text{cycles}}=\frac{6.626\times 10^{-34}\,\mathrm{J}}{\text{cycle}}. \tag{15}$$

According to Eq. (7), the energy represented by the Planck constant refers to one cycle, but as one cycle corresponds to one wavelength this contradicts equation $E=(h\times c)/\lambda$. As equation $E=h\times f$ unnaturally distributes the quantum of energy of a photon over 299 792 458 m, calculating the quantum of energy for one cycle, we must obtain of course a smaller value for the quantum of energy than according to Eqs. (5) or (6): $E=(h\times 1\,\mathrm{Hz})/\text{cycle} =(h\times 1\,\mathrm{Hz})/\lambda$. Instead of $E=h\times f$, we, therefore, have to use equation $E=q_E/\lambda$ ($q_E=h\times c$), which includes the velocity c.

As the quantum of energy of different wavelengths is always the same, the number of energetic structures that must be contained in a wavelength must always be the same in number, but must be distributed over different distances. The essence of the quantum of energy of a photon is not the frequency, but a certain number of smaller structures represented by the Planck constant and the velocity c, both referring to a certain wavelength. Considering that equation $E=h\times f$ distributes the quantum of energy of a photon over 299 792 458 m, we have to multiply the value we obtained in Eq. (15) with the distance of 299 792 458 m. Considering also that 1 cycle corresponds to one wavelength, we obtain again the correct value for the quantum of energy of a photon that we calculated in Eq. (13) or Eq. (14)

$$\begin{aligned} E_{\mathrm{ph}} &= E_{\mathrm{q}}\times 299\,792\,458\\ \mathrm{m} &= \frac{6.626\times 10^{-34}\,\mathrm{J}}{\text{cycle}}\times 299\,792\,458\,\mathrm{m},\\ E_{\mathrm{ph}} &= \frac{6.626\times 10^{-34}\,\mathrm{J}}{\lambda}\times 299\,792\,458\\ \mathrm{m} &= \frac{6.626\times 10^{-34}\,\mathrm{J}}{2.997\,924\,58\times 10^{-7}\,\mathrm{m}}\times 299\,792\,458\,\mathrm{m},\\ E_{\mathrm{ph}} &= 6.626\times 10^{-19}\,\mathrm{J}. \end{aligned} \tag{16}$$

But Cameron Rebigsol measured 97 cycles, which would mean that a photon would have a higher quantum of energy than according to Eqs. (13) and (14) if we assumed that the quantum of energy of a photon is distributed over all wavelengths of an electromagnetic radiation

$$\begin{aligned} E'_{\mathrm{ph}} &= E_{\mathrm{ph}}\times 97=\frac{q_E}{\lambda}\times 97,\\ E'_{\mathrm{ph}} &= \frac{1.986\,445\,857\times 10^{-25}\,\mathrm{J\,m}}{\lambda}\times 97,\\ E'_{\mathrm{ph}} &= \frac{1.986\,445\,857\times 10^{-25}\,\mathrm{J\,m}}{2.997\,924\,58\times 10^{-7}\,\mathrm{m}}\\ &\quad\times 97=6.427\times 10^{-17}\,J. \end{aligned} \tag{17}$$

Physicists wrongly think that the frequency is an essential factor of the quantum of energy of a photon. If we were able to move with the velocity c with the photon, we would be able to observe that there is no frequency at all, but only the wavelength of the photon. Although a photon is very short, resting against the movement of electromagnetic radiation, we observe a continuous wave movement of electromagnetic radiation over 299 792 458 m, which does not mean that the photon is 299 792 458 m long. If we drive with a colony of cars, we will not see any frequency of passing cars, but only if we are standing on the side of the road. The frequency only indirectly appears if we observe the photon when passing us. Not the frequency is the relevant factor for the strength of energy of electromagnetic radiation, which most people think, but the density of the structural component h, which is the denser the smaller the wavelength. The essence of the quantum of energy of a photon is not the frequency, but, besides the velocity c, a certain number of very small structures represented by the Planck's constant h, both referring to a certain wavelength. $E=(h\times c)/\lambda$ providing the quantum of energy of electromagnetic radiation shows that the whole energy of electromagnetic radiation must be already contained in one wavelength because of $h\times f=(h\times c)/\lambda$. Therefore, the first wavelength already contains the entire quantum energy and the following waves cannot contain the same quantum of energy again. The qualitative wrong equation $E=h\times f$ suggests that all wavelengths distributed over 299 792 458 m must have the same properties, which is wrong. Instead of equation $E=h\times f$ we have to use equation $E=q_E/\lambda$ ($q_E=h\times c$) for the quantum of energy of a electromagnetic radiation, which provides the same result.

III. TODAY PHYSICISTS SPEAK FROM A PARTICLE-WAVE DUALITY, BUT A PHOTON AND AN ELECTROMAGNETIC WAVE MUST BE TWO DIFFERENT PARTS OF ONE SINGLE PHYSICAL PHENOMENON

Going from the fact that a photon is something that moves and from the basic assumption that something that moves should have some kind of structure and a velocity, it is reasonable to assume that a photon has some kind of structure, velocity and length. Equation $E=q_E/\lambda$, respectively, equation $E=(h\times c)/\lambda$ proves several facts: (1) already the first wavelength must contain the whole quantum of energy of a photon. (2) The quantum of energy of a photon consists of a motion component represented by the velocity c and of a structural component represented by Planck's constant h. (3) As "photons" have different wavelengths, the structural component h is distributed over different spatial distances, which means that there must exist a smaller and more basic quantum of energy than that represented by Planck's constant h. The following interpretation cannot be proved but follows logical considerations. Electrons, positrons, and protons and other charged particles cause electric fields that spread with the velocity c radially from the particles that carry either a negative or a positive charge. It is reasonable to assume that something that spreads into space must have some kind of structure. Because there exist two different charged fields with different algebraic signs, there must exist two different structures that cause the charged fields. If there exist two different structures that spread from an electron, positron, or proton with the velocity c moving radially from the charged particles into space, there must in general exist two different structures that move through space with the velocity c. Electromagnetic waves are produced when electric charges are accelerated, for example, when an alternating current flows through a wire. The frequency of the photon created equals the frequency of the alternating current. As the alternating accelerated charges create photons, the two different spreading structures of positive and negative charged fields that are caused by the alternating accelerated charges of different algebraic signs must be the same structures, of which photons must consist of. The postulation of two different "basic quanta" that move through space with the velocity c corresponds with the basic postulate of my binary quantum model,[3] as it is described in my article "Unification of the unification of the four fundamental forces of nature by a binary quantum model" I named these two structures basic quanta. To distinguish between the two types of basic quanta I called them "negative basic quanta" and "positive basic quanta." If a photon has a quantum of energy of at least 1.022 MeV, a pair production can take place when the photon collides with a nucleus of atoms and there results an electron and a positron. If electrons and positrons can arise from the structures that make up photons, it is reasonable to assume that the structures of electrons and positrons are equal to the structures, of which photons consist of, and it is unreasonable to assume that the structures that build up electrons and positrons differ from the structures that make up photons. According to the binary quantum model,[3] as it is described in my articles Unification of the unification of the four fundamental forces of nature by a binary quantum model and "Refutation of Einstein's relativity on the basis of the incorrect derivation of the inertial mass increase violating the principle of energy conservation. A paradigm shift in physics,"[4] charged fields are caused by the spread of two different kinds of basic quanta, whereas basic quanta can cause all physical phenomena, causing different energy forms and even gravity and matter by different arrangements and, in the case of matter by different bindings, of the two different kinds of basic quanta. According to the binary quantum model, space shall be filled up with disordered "negative and positive basic quanta" that move in space with the velocity c. Nobody will claim that the negative electric charged field is part of an electron or the positive electric charged field is part of a positron or proton. Because an electron and a positron cause charged fields, also a photon must be able to cause charged fields, because a photon must consist of the same two kinds of basic structures, as from a photon can result an electron and a positron. According to the binary quantum model, the electron causes a negative electric charged field by an interaction with negative basic quanta of space that move disordered through space with the velocity c and hereby arranges the negative basic quanta of space so that they now move radially away from the electron in an orderly manner with the velocity c. A proton (or positron) causes a positive electric charged field by an interaction with the positive basic quanta of space that move disordered through space with the velocity c and hereby arranges the positive basic quanta of space so that they now move radially away from the proton (or positron) in an orderly manner with the velocity c. According to that, electric charged fields with different algebraic signs must be part of the contents of space, but not part of the electron, the proton or positron. But in the case of photons, physicists claim that the alternating electromagnetic charged fields called electromagnetic wave must be part of the photon and thus speak from a particle-wave duality. But the photon consists of only the first wavelength and the alternating electromagnetic charged fields called electromagnetic wave, which follow the photon must be considered to be a part of the contents of space, whereas the formerly disordered moving two sorts of negative and positive basic quanta of space move orderly behind the photon (first wavelength) with the velocity c, after the interaction between the negative and positive basic quanta of space with the structures (basic quanta) of the photon (first wavelength).

IV. EQUATION $E = q_E/\lambda$ CONFIRMS THE BASIC POSTULATE OF THE BINARY QUANTUM MODEL

Because of equation $E = q_E/\lambda$, already the first wavelength should contain the whole quantum of energy of a photon.[3] Dividing equation $E = (h \times c)/\lambda$ by the velocity c, we obtain Planck's constant h per wavelength (h/λ), which proves that the Planck constant must represent the structural component of the quantum of energy, as it would be nonsensical to postulate that something that has not some kind of structure (a not existing object) can move. This also proves that the structural component h, which is constant, must be differently distributed over different long wavelengths. This means that the structural component h must consist of smaller and more basic quanta because otherwise there cannot result a different dense distribution of the structural component h over wavelengths of different lengths. An electromagnetic wave cannot have been arisen from accelerated alternating charges and their charged fields, because the wavelength of the photon would otherwise have to be identical to the following wavelengths of the electromagnetic wave, which is not the case because the following wavelengths do not carry a quantum of energy. The electromagnetic wave must therefore have been generated by a different mechanism. The photon itself is the only option that can cause the electromagnetic wave behind the photon. But from where does the photon get the structures to generate the electromagnetic wave? Because the photon moves through space at the speed of light, the structure from which the photon generates the electromagnetic wave must be present in space. This means that space must contain the structures that build up the alternating charged fields caused by the photon, which move behind the photon as an electromagnetic wave. These structures, which must be present in space, must also move at the speed of light like the photon, otherwise they could not be able to fly behind the photon with the same speed as the photon. This proves the basic thesis of my Binary Quantum Model, which postulates that space must be filled with positive and negative tiny particles, which I called positive and negative basic quanta, that move in space with the speed of light in a disorderly manner. According to the binary quantum model, all physical phenomena, including matter, can arise by processes that order or bind the basic quanta. In order to be able to generate alternating charged fields the photon, which consists of packets of positive and negative components (negative and positive basic quanta), must be able to interact with the basic quanta of the space, whereby the previously disorderly moving basic quanta of space are ordered and form an image of the photon.

The negative and positive charged field a photon consists of (first wavelength) arises from the charged fields of accelerated alternating charges and thus from the negative and positive and basic quanta of space, which have already been ordered in the charged fields by the charges of electrons and protons, for example, in a metal wire. The following electromagnetic wave arises from initially disorderly flying negative and positive basic quanta of space. This is the reason why the negative and positive charged fields of the first wavelength (photon) consisting of ordered negative and positive quanta are complete, while the alternating negative and positive charged fields of the following electromagnetic wave will have gaps and will therefore be incomplete, although the wavelengths of the electromagnetic wave are very similar to the single wavelength of the photon. While we must assume that the photon contains a complete quantum packet of basic negative and positive basic quanta and is therefore stable, it can be assumed that the wavelengths of the following electromagnetic wave do not contain complete quantum packets of negative and positive basic quant and are therefore unstable. Therefore, by the negative and positive basic quanta flying disorderly through space, the wavelengths of the electromagnetic wave will be destroyed again after a short time but will immediately arise again and again behind the photon. If photons take the structures for their alternating electric fields behind it (electromagnetic wave) from the negative and positive basic quanta of space, which move with the speed c through space, it is also reasonable to assume that electrons, positrons and protons take the structures of their charged fields from the negative and positive basic quanta of space, so that the negative charges of electrons order the negative basic quanta of space and the positive charges of positrons and protons order the positive basic quanta of space, which then spread radially into space. I imagine the creation of an electromagnetic wave by a photon as following: A photon consists of a quantum packet of negative and positive basic quanta. By an interaction with the negative basic quanta of space with the negative basic quanta of the photon, the negative basic quanta of space arrange next to the negative basic quanta of the photon, so that there results an image of the "negative" quantum packet of the photon. At the same time by an interaction with the positive basic quanta of space with the positive basic quanta of the photon, the positive basic quanta of space arrange next to the positive basic quanta of the photon, so that there results an image of the "positive" quantum packet of the photon. On the whole, there is created an image of the wavelength of the photon by the interaction of the photon with the basic quanta of space. This image of the wavelength of the photon consists of an incomplete quantum packet, which consists of an incomplete packet of negative basic quanta and another incomplete packet of positive basic quanta. In the direction of the movement of a photon, caused by the basic quanta of space that disorderly move through space, there should result some kind of "quantum headwind" because from the front the photon should meet more basic quanta of space than from the back. As an image of the photon consisting of incomplete quantum packets of negative and positive basic quanta is affected stronger by the quantum headwind because its incomplete packets of negative and positive basic quanta must have less a density than the quantum packets of the photon, the image of the photon slides behind the photon and now flies in the "quantum slipstream" behind the photon with the velocity c. Now a second image of the photon is created by the photon, which also slides backwards and pushes the previously created image backwards, and so on, until a certain number of alternating incomplete charged fields, which are very similar to the photon, fly behind the photon. Because these images of the photon are incomplete and therefore instable packets of basic quanta, the images of the photon moving behind the photon do not carry quantum of energy and are destroyed again by the positive and negative basic quanta moving disorderly through space. Therefore, the electromagnetic waves flying behind the stable photon dissolve again after a certain number of wavelengths in order to get formed again and again behind the photon. How one could imagine the two sorts of basic quanta can be seen in Fig. 1. In contrast to my binary quantum model published in 2016, I would postulate today that long structures of basic quanta of the same algebraic sign can interact "strongly", that long structures and short structures of basic quanta of different algebraic signs can interact "weakly" and that short structures of basic quanta of the same algebraic sign can also interact weakly (latter not postulated in 2016), otherwise the unification of the electromagnetic force with gravity cannot be realized by the Binary Quantum Model, which shall be the subject of another article.

The real appearance of the basic quanta we cannot know, because they are too small to be examined directly. The illustrated central circle in Fig. 1 is only for a better differentiation of the two kinds of tiny particles, which I called negative and positive basic quanta. If the two sorts of basic quanta are really the basis of all physical phenomena, it must also be able to define the quantum of energy of a photon in its fundamental sense by the movement of the basic quanta and therefore also by their velocity c, which explains, why

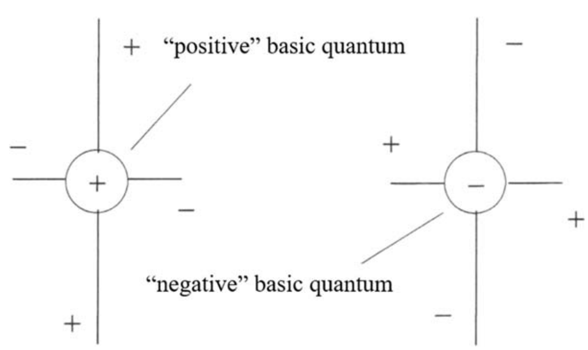

FIG. 1. Two different kinds of basic quanta simplified figured as two-dimensional structures. The basic quanta are defined with respect to the algebraic sign according to the long structure.

the velocity c must be directly associated with energy and the principle of energy conservation, where n stands for the total number of basic quanta

$$E = \frac{(E^{+}) + (E^{-})}{\lambda} = \frac{\frac{n}{2} \times \text{basic quanta}^{+} \times c + \frac{n}{2} \times \text{basic quanta}^{-} \times c}{\lambda}. \tag{18}$$

As c is according to Eq. (10) part of the quantum of energy, c must be a natural constant because of the principle of energy conservation principle. As the velocity c is part of this fundamental definition of quantum of energy, this also explains in a deeper sense, why an electromagnetic radiation would lose energy, if it moved slower than c, which is not possible because of the energy conservation principle. According to my considerations, we have two different structural components (negative and positive basic quanta) and the velocity component (c) that together represent energy.

As the Planck constant h must represent the structural components that I postulated to be the negative and positive basic quanta, for the whole quantum of energy we obtain

$$E = \frac{\left(\frac{n}{2} \times \text{basic quanta}^{+} \times c\right) + \left(\frac{n}{2} \times \text{basic quanta}^{-} \times c\right)}{\lambda},$$
$$E = \frac{n \times \text{basic quanta}^{+/-} \times c}{\lambda} = \frac{h \times c}{\lambda}. \tag{19}$$

In the case of a photon and an electromagnetic wave, packets of negative and positive of basic quanta are alternately moving behind each other, whereas only the first negative and a positive packet (first wavelength) consists of a complete set of negative and positive basic quanta causing the quantum of energy of a photon.

The equation for the quantum of energy of a photon is given by the following equation, whereas c is the velocity of light, h is the Planck constant, and λ is the wavelength:

$$E_{\text{ph}} = \frac{h \times c}{\lambda}. \tag{20}$$

We have now recognized that a natural constant representing the quantum of energy of a photon must include not only the material or structural component of quantum of energy of the photon, represented by Planck's constant h, but also the energy caused by the motion of the photon, represented by the velocity c, so that the real natural constant for the quantum of energy is q_E and not only h

$$q_E = h \times c = 6.626 \times 10^{-34}\,\text{J s} \times 299\,792\,458\,\frac{\text{m}}{\text{s}},$$
$$q_E = h \times c = 1.986\,445\,857 \times 10^{-25}\,\text{J m}. \tag{21}$$

The correct equation for a quantum of energy of a photon is therefore (with the corresponding units in brackets)

$$E_{\text{ph}}(\text{J}) = \frac{q_E\,(\text{J m})}{\lambda\,(m)}. \tag{22}$$

Dividing equation $E = (h \times c)/\lambda$ by the velocity c, we obtain Planck's constant h per wavelength (h/λ), which proves that the Planck constant must represent the structural component of quantum of quantum of energy.

This also proves that a wavelength carrying quantum of energy must contain always the same number of basic quanta, as Planck's constant is constant. If the wavelength is large, the basic quanta must therefore be distributed over a larger distance, than if the wavelength is smaller. The basic quanta might represent what the ancient Greek philosophers called "substance." The number of basic quanta that build up the energy of one quantum we will never know, as the basic quanta that are postulated to be the substance of everything are two small to be able to be directly examined. Electromagnetic radiation, which physicists today call once electromagnetic wave and once photon, consists of two parts. We should therefore better define electromagnetic radiation as photon-waves. The first part of a photon-wave is the photon (first wavelength) that carries an quantum of energy and has particle properties, and the second part consists of the wavelengths that fly behind the photon and does not carry an quantum of energy, which can still be called electromagnetic wave. But the electromagnetic wave consists of alternating incomplete charged fields caused by the photon and therefore consists of instable packets of basic quanta that quickly dissolve again in space, but which are just as quickly formed again and again behind the photon, so that they can be perceived and measured as a seemingly constant wave. We can imagine the electromagnetic waves behind the photon like the contrails behind a jet plane (which in this case would resemble the jet plane), which dissolve, but form again and again behind the jet plane, with the difference that the "contrails" follow the photon because of their velocity c. Because electromagnetic radiation consists of two parts it partially behaves like particles (photon), for example, at the Compton Effect, and partially like a wave. At the Compton effect, X rays or other energetic electromagnetic radiation collides with electrons. The photons of the photon-waves get elastically scattered by the electron and the wavelength the photon increases in dependence of the angle of collision. By the collision with electrons the negative and positive basic quanta that build up the photon of a photon-wave are hindered in their flight and scattered in space, depending on the collision angle, so that after the collision they are more distributed and the wavelength of the photons increases. The resulting lower density of negative and positive basic quanta, which also means that the structural component h of a quantum of energy (Planck's constant) is distributed over a larger wavelength after the collision, is responsible for the energy loss of the photons. The energy that gets lost by an increase in the density of the two packets of basic quanta of a photon is transferred to an electron. As the motion component c of energy is constant, only the density of basic quanta and the number of basic quanta are responsible for the different energy contents of physical objects. Different wavelengths of photons must contain the same number of basic quanta, as the structural component h of the quantum of energy of photons is constant.

V. ACCORDING TO THE NATURAL QUANTUM CONSTANT q_E, WHICH REPRESENTS THE QUANTUM OF ENERGY PER WAVELENGTH, WE HAVE TO DEFINE THE SPIN OF PARTICLES IN A NEW WAY

The spin of a particle is defined by the so-called reduced Planck constant

$$E_{\rm ph} = h \times f = \hbar \times \omega = \hbar \times 2\pi \times f, \quad \hbar = \frac{h \times f}{\omega} = \frac{h \times f}{2\pi \times f} = \frac{h}{2\pi}. \tag{23}$$

Using the equation for the quantum of energy,

$$E_{\rm ph} = \frac{q_E}{\lambda}. \tag{24}$$

We obtain for the reduced Planck constant

$$\hbar \times 2\pi \times f = \frac{q_E}{\lambda}, \quad \hbar = \frac{q_E}{2\pi \times f \times \lambda}. \tag{25}$$

Because of $q_E = h \times c$, we obtain

$$\hbar = \frac{h \times c}{2\pi \times f \times \lambda}. \tag{26}$$

Spin 1 defined by the reduced Planck constant and the natural constant q_E is according to that

$$S = 1\hbar = \frac{h \times c}{2\pi \times f \times \lambda}. \tag{27}$$

From this equation, we can directly see that the spin of a particle also happens with the velocity c.

VI. THE INTERFERENCE PATTERN OF ELECTROMAGNETIC RADIATION AT DOUBLE-SLIT EXPERIMENTS AND AT EXPERIMENTS USING PARAMETRIC CONVERTERS AND BEAM SPLITTERS CAN NOW BE EXPLAINED IN A CAUSAL WAY BY AN INTERFERENCE OF THE TWO PARTS OF PHOTON-WAVES

As explained above, in reality there does not exist the so-called wave-particle duality of electromagnetic radiation, which only stands for two aspects of a single physical phenomenon, which we call electromagnetic wave or photon, depending on which aspect of a photon-wave we consider. But what happens at the so-called double-slit experiments? The photon (first wavelength representing the quantum of energy) of the photon-wave is disturbed by the material that limits one of the slits when it wants to pass through the slit, which causes that the photon separates from the following electromagnetic wave of the photon-wave. After the separation from the photon, the following electromagnetic wave only exists for a short time and dissolves quickly in space. As the electromagnetic wave does not carry a quantum of energy, it cannot cause an interference pattern at the screen or detector. The quickly dissolving electromagnetic wave of a photon-wave is the hidden variable that lets us understand the strange behavior at double-slit experiments or at experiments with beam splitters in a classical way. While the photon of the photon-wave passes through the one slit, it gets separated from the following wavelengths of the electromagnetic wave, which passes through the other slit. Nevertheless, the photon will cause immediately a new electromagnetic wave behind it. After both parts of the photon-wave have passed through the two different slits, they can interfere with each other, which causes an interference pattern on the screen caused by the photon of the photon-wave, whereas the separated electromagnetic wave cannot cause a pattern on the screen.[4] At experiments using beam splitters, there also happens a separation of the photon from the electromagnetic wave at the beam splitter. If we let the two parts of the photon-wave meet each other again, there can also be seen an interference pattern. If we interrupt the path for one of the two parts of the photon-wave, this interaction between the photon and the electromagnetic wave of the photon-wave cannot take place, and thus, no interference pattern can arise. The result has nothing to do with some mental influence of the researcher, as it is usually postulated by today's quantum mechanics.[6–10] In my article, "Failure of the standard interpretation of quantum mechanics—Three experimental falsifications, and a consistent alternative interpretation", I proved that today's interpretation of quantum physics must be wrong and that all these experiments can be explained in a causal and classical way.[11] I explained the interference pattern by a "phantom particle" accompanying a photon. Now we discovered that the photon and the electromagnetic wave are the two parts of a photon-wave. That a photon-wave is able to interfere with "itself" at a single slit is now no problem anymore because it consists of two different parts. But larger particles than photons, as, for example, electrons or positrons, as well as even larger particles, e.g., atoms and molecules, will also interact with the basic quanta of space and will cause some kind of more complex image of themselves that can still be named phantom particle, which must also be able to interfere with the real particle. About the explanation of quantum experiments investigating spins of entangled electron see chapters IV–VII in my former article: Failure of the standard interpretation of quantum mechanics—Three experimental falsifications, and a consistent alternative interpretation.[3] In 1926, the German physicist Max Born postulated that interference can only happen between pairs of quantum objects, causing their wavelike forms to boost and diminish one another. Triplets, quadruplets, or more shall not be able to interfere. Therefore, Born put interference contributed by a third slit (and any more slits) at exactly zero. In a triple-slit experiment by Sinha *et al.*,[12] only pairwise interferences could be measured, but no three way interference, which confirmed the postulate of Born, but also verifies my imagination, that a photon-wave must consist of two parts. The reason why quantum interference stops at two slits cannot be derived from "Born's rule" in the sense of a deeper principle about the way the quantum world functions, but can now be understood by my considerations according to that electromagnetic radiation consists of two parts. The photon that is able to cause an interference pattern cannot be divided at slit experiments. If many photons are send through a triple slit, the electromagnetic waves of the photons are destroyed by the photons when passing the slits. Sending only a single photon through the triple slit, the photon moves through one slit, but its electromagnetic wave is divided at a triple-slit and the two parts of the electromagnetic wave will interfere with each other, which destroys the instable parts of the electromagnetic wave, so that an interference between the electromagnetic wave and the photon also is prevented.

VII. NOW WE ARE ABLE TO ANALYZE AN IMPORTANT EXPERIMENT OF LEONARD MANDEL OF THE UNIVERSITY OF ROCHESTER IN THE NINETIES OF THE LAST CENTURY

First, I still use the definition of photons, as it is common today: Beam splitters are optical components used to split light at a certain ratio into two separate beams.[13] One photon reaching a beam splitter has, for example, a 50/50 probability to pass through the beam splitter or to be reflected at the beam splitter. Today's quantum mechanics of basic quantum phenomena postulates that at a beam splitter a photon or another quantum object moves both paths if we do not try to measure, which path the photon moves and also if we cannot know, which path the photon has moved. To explain this behavior, it is imagined that photons behave like probability waves, which collapse when we try to measure them. Only if we are able to gain which-path information, the photon represented by a probability wave shall collapse and be forced to take one path and either gets reflected at the beam splitter or passes through, but without the possibility of gaining which-path information the photon represented by a probability wave shall not collapse and the status of the quantum object photon shall keep being undefined so that it must take both paths. In an important experiment of Leonard Mandel[13] of the University of Rochester in the nineties of the last century a laser fires light at a beam splitter, see about this in Fig. 2.

In the experiment, Mandel could either register only the counting rate at the detector D_s (= R_s), or register only the counting rate at the detector D_i (= R_i), but also the coincidence counting rate between the detectors D_s and D_i, (R_{si}). Typical counting rates are about 5000/s for R_i, 400/s for R_s and 4/s for the coincidence rate R_{si}. In the experiment, Mandel examined a second-order interference by counting the detections at the detector D_s. Reflected photons are directed to one down-converter (NL2), while transmitted photons go to another down-converter (NL1). Each down-converter splits any photon impinging on it into two lower-frequency photons by a BBO (barium borate crystal) one called the signal and the other called the idler. The two down-converters are arranged so that the two idler beams merge into a single beam. Mirrors steer the overlapping idlers to one detector and the two signal beams to a separate detector. In front of the detector D_s, an interference can happen at the beam splitter BS_0. This design does not permit an observer to tell which way any single photon went after encountering the beam splitter. According to established quantum mechanics, each photon therefore seems to go both ways, right and left at the beam splitter BS_p like a wave and passes through both down-converters, producing two signal wavelets and two idler wavelets. Subsequently the signal wavelets generate an interference pattern at the detector D_s. The pattern is revealed by gradually lengthening the distance that signals from one down-converter must go to reach the detector. As the down conversion happens spontaneous, the signal photons and the idler photons, once emitted by the down-converters, never again cross paths. Nevertheless, simply by blocking the path of one set of idler photons or by misalignment of the two idlers, the researchers destroy the interference pattern of the signal photons, see about this in Fig. 3.

That by a misalignment of the two idler photons, the researchers can destroy the interference pattern of the signal photons, indicates a causal process. But the only answer Mandel can give us is that the observer's potential knowledge has changed:[13] "In this case one can determine, which route the signal photons took to their detector by comparing their arrival times with those of the remaining, unblocked idler photons. The original photon seems therefore no longer able to go both ways at the beam splitter, like a wave, but

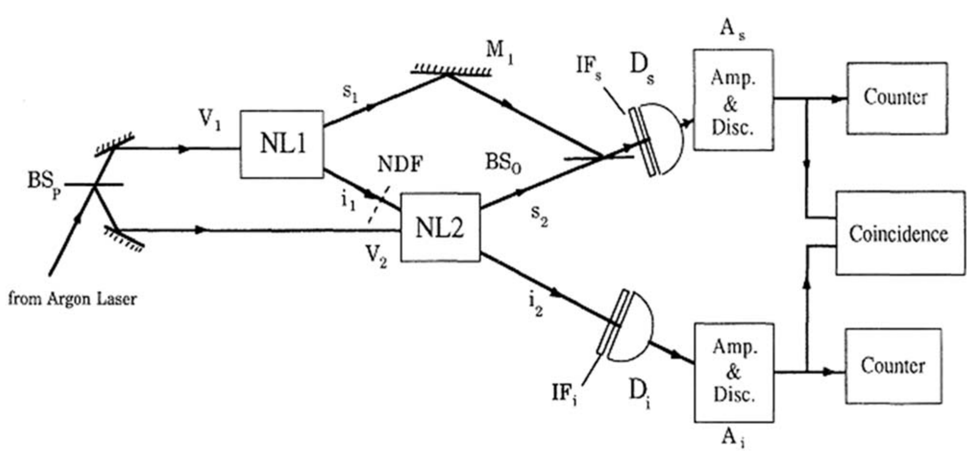

FIG. 2. The schematic experimental setup of the experiment by Mandel *et al*.

must either bounce off or pass through like a particle." "A quite mystical interpretation, which today's quantum physicists believe to be real." Mandel writes in his article on page 3 (page 320 of the paper):[13] "All interference effects vanish, when the idlers i_1 and i_2 are effectively disconnected from each other. This phenomenon appears strange…. Moreover, (as) i_1 emission by NL1 and s_2 emission by NL2 almost never accompany each other." In other words: The emission of the idler photon i_1 by NL1 is almost never accompanied with the emission of the idler photon i_2 by NL2, while the emission of the signal photon s_2 by NL2 must always happen at the same time with the emission of the idler photon i_2 by NL2. If the original photon would move both paths at the beam splitter, as it is the dogma of today's quantum mechanics, every emission of an idler photon i_1 by NL1 must be accompanied with the emission of an idler photon i_2 by NL2. But in the experiment, the idler photon i_1 by NL1 is almost never accompanied by the idler photon i_2 by NL2. In other words: Mandel's experimental result contradicts his own postulation that each photon must have moved both paths at a beam splitter at the beginning of the experimental device, at least if an interference happened. According to my considerations, we can postulate more qualities of the electromagnetic wave of the photon-wave representing only wavelengths without an quantum of energy, which I called phantom-particle in my former article.[11] (1) The electromagnetic wave of a photon-wave is not able to cause a pattern itself on a screen or detector of double-slit or similar experiments. (2) The electromagnetic wave of a photon-wave occupies space, as it also consists of packets of basic quanta. (3) If the photon of a photon-wave gets reflected at a beam splitter, the electromagnetic wave of the photon-wave will not be separated completely, but a part of the following electromagnetic wave will get separated from the photon and move straight through the beam splitter, while a part of the electromagnetic wave will be reflected together with the photon. (4) If the photon of the photon-wave moves through the beam splitter, a part of the electromagnetic wave will keep

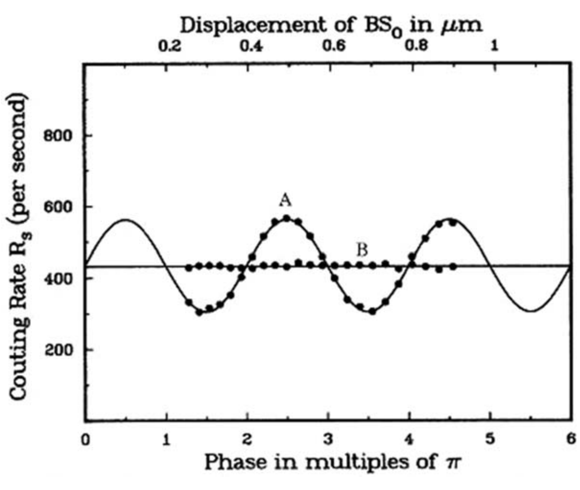

FIG. 3. Measured photon counting rate as a function of beam splitter BS_0 displacement. Curve A: Neutral-density filter between NL1 and NL2 (interference). Curve B: Beam stop inserted between NL1 and NL2 (no interference).[13]

attached to the photon and will pass through the beam splitter with the photon, while another part of the electromagnetic wave will get reflected at the beam splitter. (5). A separated part of the electromagnetic wave should partially move through and partially be reflected at the beam splitter. (6) At a downconverter containing a BBO (barium borate crystal) the quantum of energy of a photon is divided into two parts, from which result two photons with half of the former quantum of energy. Because the electromagnetic wave does not carry an quantum of energy, it cannot be divided at the downconverter. Therefore, the electromagnetic wave moves either the one or the other way after the down-converter (BBO). (7) At a usual mirror, which reflects all photons, also the electromagnetic wave that follows the photon should get reflected with the photon. (8) At a lens, a separated electromagnetic wave of a photon-wave should get deflected the same way, as the photon of the photon-wave. (9) A photon that is separated from its following electromagnetic wave will immediately cause a new electromagnetic wave behind it after the separation. Let us fist analyze the experimental situation with an inserted beam stop by a neutral-density filter (NDF) with a transmission rate of 0. Taking the first case: The photon of a photon-wave gets reflected at the beam splitter (BS_p) and moves with its attached part of the electromagnetic wave towards the down-converter NL2, where the photon gets split, so that the idler photon of the photon-wave i_2 together with a an electromagnetic wave can be detected at the detector D_i and the signal s_2 photon of the photon-wave together with an electromagnetic wave can be detected at the detector D_s. In front of the detector D_s, the signal photon of the photon-wave s_2 can interfere with the separated part of the electromagnetic wave of the original photon-wave, when it moves the upper way through the down-converter NL1, either towards the detector D_i (no interference can happen) or to the detector D_s (an interference can happen). An interference pattern can be registered in half of the cases. Taking the second case: The photon of a photon-wave and its attached part of the electromagnetic wave of the photon-wave moves through the beam splitter towards the down-converter NL1, where the photon of the photon-wave gets split. In this case, a part of the electromagnetic wave of the photon-wave gets reflected at the beam splitter as a separated electromagnetic wave and moves towards the down-converter NL2 and afterwards either towards the detector D_s or the detector D_i. If the separated electromagnetic wave of the photon-wave moves towards the detector D_s, it can interfere with the signal photon of the photon-wave s_1 coming from the down-converter NL1. If the separated electromagnetic wave of the photon-wave moves towards the detector D_i, no interference can happen with the signal photon of the photon-wave s_1. An interference pattern can be registered in half of the cases. But why could not Mandel register an interference pattern in the case that a beam stop by a neutral-density (NDF) filter with a transmission rate of 0 was inserted between the down-converters NL1 and NL2 or with a misalignment of the path of the idler photon i_1 and the idler photon i_2? This is easy to explain: It is important to consider that Mandel examined a second-order interference by counting the detections only at the detector D_s (no coincidence rate.) Typical counting rates were about 400/s for R_s. In the case the photons of the photon-waves move through the beam splitter towards the down converter NL1, the signal photons of the photon-waves s_1 interfere with the beam of separated electromagnetic waves coming from the down converter NL2, so that the signal photons of the photon-waves s_1 get deviated in front of the detector D_s towards the left. In the case the photons of the photon-waves get reflected at the beam splitter and move towards the down converter NL2, the signal photons of the photon-waves s_2 interfere with the beam of separated electromagnetic waves coming from the down converter NL1, so that the signal photons of the photon-waves s_2 get deviated in front of the detector Ds towards the right. A higher counting rate at the one interference pattern is, therefore, compensated by a lower counting rate at the other interference pattern. And a lower counting rate at the one interference pattern is compensated by a higher counting rate at the other interference pattern. On the whole, we cannot see both interference patterns, as they cancel out each other, what was interpreted by Mandel that no interference happened at all.

Second, let us analyze the experimental situation *without* a beam stop by a neutral-density filter (NDF) with a transmission rate of 0 inserted between the down-converters NL1 and NL2 or without a misalignment of the path of the idler photon of the photon-wave i_1 and the idler photon of the photon-wave i_2. A laser fires photon-waves towards the beam splitter BS_p. See about this again Fig. 2. Reflected photons are directed to the down-converter (NL2), while transmitted photons move to the down-converter (NL1). If a photon of a photon-wave moves through the beam splitter, the following electromagnetic wave will partially keep attached to the photon of the photon-wave, but partially the electromagnetic wave will be separated from the photon of the photon-wave and will be reflected at the beam splitter. If the photon of the photon-wave gets reflected at the beam splitter, the following electromagnetic wave will partially keep attached to the photon of the photon-wave, but partially will move through the beam splitter as a separated part of the electromagnetic wave of the photon-wave. The down-converter NL1 splits each photon of the photon-waves impinging on it into two lower-frequency photon of photon-waves one called the signal photon and the other called the idler photon. The down-converter NL2 splits each photon of the photon-waves impinging on it into two lower-frequency photon one called the signal photon and the other called the idler photon. But the separated part of the "electromagnetic radiation" does not carry an quantum of energy and therefore cannot be divided at the BBO (barium borate crystal), so after the down-converter NL1 or NL2 the (at the beam splitter) separated part of the electromagnetic wave either moves upwards in the direction of the detector D_s or it moves downwards towards the detector D_i. Taking the first case: The photon of a photon-wave with its attached part of the electromagnetic wave moves through the beam splitter towards the down-converter NL1, where the photon of the photon-wave gets split. In this case, a part of the electromagnetic wave gets reflected at the beam splitter as separated electromagnetic radiation and moves towards the down-converter NL2 and afterwards either towards the detector D_s or the detector D_i. But we have to consider that without a beam stop on the path of the idler photon of the photon-wave i_1 or without a misalignment of the path of the idler photon of the photon-wave i_1, the beam of parts of (at the beam splitter) from the photon separated electromagnetic waves, which move towards the detector D_S after the down converter NL2, must pass the beam of idler photons of the photon-waves i_1 (very close), which is necessary to keep the path of the idler photons of the photon-waves i_1 and i_2 connected. In this case, we must expect that the beam of parts of (at the beam splitter) from the photon separated electromagnetic waves gets destroyed or scattered by the beam of idler photons of the photon-waves i_1. The destroyed or scattered beam of parts of separated electromagnetic waves that move towards the detector D_s after the down converter NL2 can now not interfere any more with the signal photon of the photon-wave s_1 coming from the down-converter NL1: No deviation of the signal photons of the photon-waves s_1 towards the left happens in front of the detector and no interference pattern can be registered in this case. Taking the second case: The photon of a photon-wave gets reflected at the beam splitter and moves with its part of attached electromagnetic wave towards the down-converter NL2, where the photon of the photon-wave gets split, so that the idler photon of the photon-wave i_2 can be detected at the detector D_i and the signal photon of the photon-wave s_2 at the detector D_s. Without a beam stop on the path of the idler photons of the photon-waves i_1 or without a misalignment of the path of the idler photons of the photon-waves i_1, the beam of parts of (at the beam splitter) from the photon separated electromagnetic waves, which move towards the detector D_i after the down converter NL1, must pass the beam of signal photons of the photon-waves s_2 very close, which is necessary to keep the path of the idler photons of the photon-waves i_1 and i_2 connected. But this does not influence the no-interference detection of the signal photon of the photon-wave s_2 at the detector D_s. But if the beam of parts of separated electromagnetic waves moves towards the detector D_s after the down converter NL1, the beam of parts of separated electromagnetic waves can still interfere with the signal photons of the photon-waves s_2 at the detector D_s as usual. A deviation of signal photons of photon-waves s_2 towards the right happens in front of the detector as usual and an interference pattern can be registered in this case. The not visible interference pattern of the experimental setting without a beam stop gets unmasked. The counting rate shown in Fig. 3 at the detector D_s is about 430/s for R_s. According to my interpretation of the experiment, half of the photons of the photon-waves detected at D_s can interfere with parts of separated electromagnetic waves coming from the converter NL2, if there is a beam stop inserted between the down converter NL1 and NL2, but the opposite two interference pattern cancel out each other, as described above, so that we get a line for the detection rates, measured at certain positions of the detector D_s, as shown as curve B in Fig. 3. If there is no beam stop inserted, only a quarter of the counting rate (about 110/s) can cause an interference pattern by an interference between the beam of parts of separated electromagnetic waves moving from the down converter NL1 towards the detector D_s and the beam of signal photons of photon-waves s_2 moving from the converter NL1 towards the detector D_s. As the total counting rate at the detector D_s does not change and is still about 430/s for R_s, the counting rate varies between a counting rate of about 540/s and 320/s and we get a wave shaped curve for the detection rates, measured at certain positions of the detector D_s, as shown as curve A in Fig. 3. This corresponds with the result of the experiment. According to my imaginations, their can only happen a deviation of signal photons of the photon-waves s_2 towards the right, but not a deviation of signal photons of the photon-waves s_1 towards the left. Starting from the position where curve A intersects line B on the left side of Fig. 3 for the detection curve A, we expect a higher detection rate shifted to the right side and a corresponding lower detection rate shifted to the left side in comparison to the detection curve B. Starting from the position where curve A intersects line B on the right side of Fig. 3, for the detection curve A we expect a higher detection rate shifted to the right side and a corresponding lower detection rate shifted to the left side in comparison to the detection curve B. This explains exactly the registered interference pattern of second order, as measured by the experiment of Mandel and shown as curve A in Fig. 3. Mandel's experiment and other similar experiments[5–9] can be explained in a causal way by recognizing that what we call particle-wave duality is one physical phenomenon, which I called photo-wave. The electromagnetic wave is the famous hidden variable that today's physicists cannot recognize, because they think that the electromagnetic wave and the photon represent the same physical phenomenon.

VIII. PARADOXES OF QUANTUM MECHANICS VANISH AND WE RECOGNIZE THAT EINSTEIN WAS RIGHT WITH HIS CLAIM: GOD DOES NOT PLAY DICE!

Today's physicists interpret experiments like that that of Mandel[13] that "which-way" information is not obtainable, if we examine quantum phenomena. Even after a particle has already taken a certain path, it should be able to change its formerly taken path afterwards. Because only the quantum of energy of the photons (first wavelength) of a photon-wave can cause a pattern on the screen of interference experiments, while the electromagnetic wave of the photon-wave that follows the photon carries no or only an incomplete quantum of energy and cannot cause a pattern on the screen, there results a seemingly strange behavior of photon-waves at single or double-slits. If we use a light beam consisting of many photon-waves passing a single slit, no interference pattern can be seen on the screen. If we let individual photon-waves pass through the single slit one after the other, there results an interference pattern on the screen. According to today's physics, it is claimed the following: When information exists about which way the particle moved, the paths are distinguishable, and no interference is possible. Going from the knowledge that a photon-wave consists of two parts, a photon represented as (complete) an quantum of energy and a following electromagnetic wave consisting of no or an incomplete quantum of energy, we can also understand, what happens at a single slit. Let us first consider the case that we let individual photon-waves pass through the single slit one after the other. The slit must be so tight that the photon can just squeeze through the slit. When a photon passes the slit, it is hindered down slightly for a moment by the side walls of the slit, which causes that the following electromagnetic wave is turned off, so that it must pass the slit separately above or below the photon of the photon-wave. After both parts of the photon-wave have passed the slit, they interfere with each other. Now we consider the situation when a light beam of many photon-waves want to pass the single slit. In this case, the passing of many photons, the instable electromagnetic waves are destroyed by the many photons that try to squeeze through the slit, so that no interference pattern can arise. The behavior of photon-waves at a single slit, at double-slits and at beam splitters can now easily be understood. The physicists, who do not understand the underlying physical process, solved the problem as usually mathematically, so that correct predictions can be calculated without understanding the underlying physical phenomena. The mathematical conceptions that also enables experimenters to predict very accurately the experimental results using double-slits and beam splitters is the so-called probability wave. In its mathematical form, it is analogous to the description of a physical wave, but its waves indicate levels of probability for the occurrence of certain phenomena that can be observed, e.g., on a detector screen. The probabilities of the so-called "non-classical" interference can be calculated by the Feynman amplitude representing the probability of detecting a coincidence rate, which is in this case zero. "Probability amplitudes of indistinguishable paths are summed, then absolute squared, to yield the probability, this leads to interference terms. Probabilities of distinguishable paths are summed yielding no interference." Thus, it is the distinguishability of alternative paths, which prevents interference. When information exists about which way the particle went, the paths are distinguishable, and no interference is possible. To calculate for example, whether a photon has passed a double-slit as a particle or a wave, the mathematical term of a wave-function is used, which collapses, if one tries to measure, through which of the two slits the photon has moved. This phenomenon, in which a wave-function, initially is in a superposition of different possible "eigenstates", appears to reduce to a single one of those states after interaction with an observer. In simplified terms, it is the reduction of the physical possibilities into a single possibility by the interaction with an observer. When, for example, a photon propagates through a double-slit apparatus, it behaves like a wave. Yet, if it is observed, the non-local wave collapses into a single localized particle. Quantum mechanics deals with wave-functions, which describe the probability amplitude of the quantum state of a particle and how it behaves. Typically, its values are complex numbers and, for a single particle, it is a function of space and time. The laws of quantum mechanics (the Schrödinger equation) describe how the wave function evolves over time.

The most common symbols for a wave function are ψ or Ψ, although ψ is a complex number, $|\psi|2$ is real, and corresponds to the probability density of finding a particle in a given place at a given time, if the particle's position is measured. The probability to find either a photon behind the one or behind the other slit of the double-slit is, according to quantum mechanics,

$$1 = (\frac{1}{\sqrt{2}}|\psi(x_{1,2},t)|)^2 + (\frac{1}{\sqrt{2}}|\psi(x_{1,2},t)|)^2. \tag{28}$$

In other words, $|\Psi(x_1,t)|^2$ and $|\Psi(x_1,t)|^2$ are the probability densities that the particle is at the position x_1 or x_2 behind the double-slit. When the particle is measured behind one of the slits, according to quantum mechanics, one of the wave-functions is said to collapse, so that the probability to find one of the photons behind one of the slits of the double-slit is

$$0.5 = \left(\frac{1}{\sqrt{2}}|\psi(x_{1,2},t)|\right)^2. \tag{29}$$

This corresponds with the classical probability to measure a particle behind one of the double-slits. According to my considerations above, we have to give up the Copenhagen interpretation of quantum mechanics that a pair of particles or photons has an indeterminate state with respect to the spin or polarization, until it is measured. Because the states of objects used in quantum experiments are determined before the measurement is performed, whereas the states cannot be known, before they are measured, we do not need the imagination of a collapsing wave-function any more. For example, it is determined before the measurement, through which slit of the double-slit the photon and the electromagnetic wave of a photon-wave has been moving though. Not understanding what happens at single slit, double slit and similar experiments with parametric converters, today's physicists postulate that the states of quantum objects are indeterminate till we measure the state of the quantum object. That's why today's physicists must again believe in miracles, when they claim that measuring the state of a quantum particle like an electron can instantly change the state of an entangled electron, even if the electrons are light-years away from each other.

IX. CONCLUSION AND DISCUSSION

Today's physicists speak from a particle-wave duality. Therefore, what happens in experiments using a single slit, double-slits, or beam splitters, they cannot understand and they cannot recognize the hidden variable, which is the electromagnetic wave that flies behind the photon, which consists of alternating incomplete charged fields caused by the photon. The mystic physics of today's quantum mechanics can now be abandoned, which believes that, when we are able to gain which-path information, the electromagnetic represented by a mathematical probability wave shall collapse and be forced to take one path, but without the possibility of gaining which-path information the electromagnetic wave represented by a mathematical probability wave shall not collapse and the status of the quantum object shall keep being undefined so that it must take both paths. In equation, $E = q_E/\lambda = (h \times c)/\lambda$, the distance of 299 792 458 m is the necessary distance for describing the velocity c. Only by using the distance of 299 792 458 m, expressed by the value for the velocity c, we obtain the correct value for the quantum of energy. But there results a problem if we want to calculate the quantum of energy by equation $E = h \times f$. Before this is possible, we have to stretch the size of a photon from one wavelength λ to 299 792 458 m by referring the quantum of energy not to one wavelength, as in equation $E = q_E/\lambda = (h \times c)/\lambda$, but to the distance of 299 792 458 m. By doing this, the distance of 299 792 458 m that is contained in the velocity c is cancelling out, and we obtain equation $E = h \times 1/\mathrm{s} = h \times \mathrm{Hz}$. Distributing the quantum of energy to the distance of 299 792 458 m is the precondition that we obtain the correct value for the quantum of energy by multiplying Planck's constant h by the frequency of a photon. The problem that results in this case is the fact that a photon does not have the size of 299 792 458 m and is therefore described by equation $E = h \times f$ in a unrealistic way, which is not considered among today's physicists. As demonstrated, we can refer the quantum of energy to any distance instead of to the wavelength λ of photons, which is the natural size of a photon, e.g., to the distance of 10×10^6 lightyears. Multiplying the value we obtain by the number of wavelengths that fit into the distance of 10×10^6 light years, we will obtain the correct value for the quantum of energy. Another problem is that equation $E = h \times f$ suggests that all wavelengths must have the same properties, which prevents physicists from thinking that it might be different. Equation $E = q_E/\lambda$ ($q_E = h \times c$) for the quantum of energy of a photon proves that the quantum of energy of a photon must already be contained in one wavelength and has not only a structural component (h), but has also a motion component represented by the velocity c. In reality, electromagnetic radiation is only one physical phenomenon, consisting of two parts. Therefore, a better word for electromagnetic radiation would be photon-waves, respectively, photon-wave. The quantum of electromagnetic radiation is located in the first wavelength, which represents the particle called photon consisting of one packet of negative and one packet of positive small structures that are distributed over different distances, which we call wavelength. This small negative and positive structures, which I called negative and positive basic-quanta, are represented by the Planck Constant h. The electromagnetic waves that move behind the photon, are alternating incomplete charged fields caused by the photon and therefore consist of instable packets of basic quanta that quickly dissolve again in space, but which are just as quickly formed again and again behind the photon, so that they can be perceived and measured as a seemingly constant wave. The photon that generates the electromagnetic wave must from somewhere get the structures for generating the electromagnetic wave that flies behind it with the velocity c. This confirms the basic thesis of my "binary quantum model"[3] that space must be filled with some kind of basic negative and positive quanta, which must fly with the velocity c through space. While an electric field of a charged particles, e.g., of electrons or positrons, moves radially away from the particle and cannot separated from the charged particle, the incomplete negative and positive charged fields that move behind the particle photon as an electromagnetic wave can be separated from the photon and can interfere with the photon at double-slit and similar experiments, as explained above.

Juliana Brooks recognized that the fundamental particle of light must be a single wave.[14] She claimed that the wave and the particle of light are not simply dual, but that they are identical. Her considerations are based on the assumption that the Planck's energy constant represents the mean energy of a single oscillation of light, namely 6.626×10^{-34} J/oscillation. But this energy value does not correspond with the quantum of energy of electromagnetic radiation, as it does not consider the motion component of the quantum of energy represented by the velocity c of electromagnetic radiation. Planck's "quantum of action" h can appear in the description of different forms of energy and physical processes, but in the case of electromagnetic radiation it is not a continuous quantum of action of the oscillations of electromagnetic radiation because it represents only the structural part of the quantum of energy of the first wavelength of a photon-wave. In its most basic meaning, the Planck constant h is a measure for the structural component of the quantum of energy of a photon consisting of one packet of always the same number of negative basic quanta and one packet of always the same number of positive basic quanta, which are packed differently dense, depending on the wavelength of the photon. There always exist more than one method to calculate and predict physical phenomena, e.g., Andrew Worsley postulates the "harmonic quintessence."[15] He claims that the wavelength of a single harmonic quintessence oscillator is equivalent to the number of meters traveled by light per unit time. The wavelength of one single "quintessence quantum" is, according to Worsley, 299 792 458 m, independent of which unit of time is chosen. The definition of a harmonic quintessence that has per wavelength a length of 299 792 458 m distributes the quintessence quantum also over unrealistic 299 792 458 m like equation $E = h \times f$ distributes the quantum of a photon over unrealistic 299 792 458 m, so that there also results a contradiction with the smallness of quantum objects, as for example of a photon, which carry the quantum of energy. Therefore, Worsley's theory of harmonic quintessence that can exactly describe units and particles must be judged to be another successful, but artificial mathematical theory.

Equation $E = h \times f$, which is celebrated as a milestone in physics and is commonly accepted, describes a photon, respectively, an electromagnetic wave in a way that does not represent the nature of electromagnetic radiation, although it provides precise quantitative results for the quantum of energy. Equation $E = h \times f$ is a simple example that reflects the problem of today's mathematized physics. Mathematics involves the risk that physicists describe a mathematical physics that provides correct quantitative results, which is an artificial physics that does not correspond with reality. $E = h \times f$ has been used for about 100 years, but physicists have not noticed that $h \times f$ describes a shape of photons, respectively, of electromagnetic waves, which does not exist in reality. Most physicists today equate predictability with truth, respectively, with reality, which is a fallacy. Occam's razor is most important to differentiate between realistic and artificial theories. While, "Newtonian quantum gravity"[16] needs, besides Newton's theory of gravity and Kepler's second law, only the additional postulate that gravity is transmitted by gravitational quanta, which move away from a mass, to predict so-called general relativistic phenomena, e.g., the curvature of a light beam at the surface of the Sun, the correct precession of Mercury's perihelion or the phenomena observed at the binary pulsar PSR B1913 + 16, Einstein's general relativity needs many additional postulates to predict these phenomena and is therefore recognized by Occam's razor to be an unrealistic theory, although general relativity is generally accepted today and most physicists believe that it describes the mentioned phenomena in a realistic way. Even though physicists do not understand a physical phenomenon, they are able to develop mathematical methods to predict it. For example, gravity: Einstein developed a method of a mathematically defined four-dimensional space-time that can make very good predictions of gravitational effects. The mathematically defined Higgs mechanism describes, how elemental particles get their mass. Why should nature need the Higgs boson with about 245×10^9 times a larger mass than the electron to give the electron its mass back, which before has been taken from the electron by physical theorist? Nature needs the Higgs boson only because otherwise there would result contradictions to the physical theories accepted today. There results a cyclic confirmation: The Higgs boson confirms the standard model of particle physics that includes Einstein's special relativity, and the standard model confirms the Higgs boson. If Einstein's special relativity was wrong, there would nevertheless be the impression that the Standard Model and the Higgs boson are real and indirectly confirm Einstein's special theory of relativity, so that physicists would not be able to recognize that the Standard Model, the Higgs mechanism, and Einstein's special relativity are not real.

[1]See https://science21.cz/conference/ for "International conference in Prague, Physics Beyond Relativity," 18–21 October, 2019.
[2]https://www.gsjournal.net/Science-Journals/Research%20Papers/View/8644
[3]R. G. Ziefle, Phys. Essays **29**, 81 (2016).
[4]R. G. Ziefle, Phys. Essays **33**, 466 (2020).
[5]T. Young, Philos. Trans. R. Soc. London **94**, 1 (1804).
[6]C. O. Alley, O. G. Jakubowicz, and W. C. Wickes, "Results of the delayed-random-choice quantum mechanics experiment with light quanta," in *Proceedings of the 2nd International Symposium on Foundations of Quantum Mechanics (Phys. Soc. Japan, Tokyo*, 1986), Vol. 36.
[7]J. A. Wheeler, *Mathematical Foundations of Quantum Theory* (Academic Press, 1978).
[8]Y. Kim, R. Yu, S. P. Kulik, Y. H. Shih, and M. O. Scully, Phys. Rev. Lett. **84**, 1 (2000).
[9]S. P. Walborn, M. O. Terra Cunha, S. Pádua, and C. H. Monken, Phys. Rev. A. **65**, 033818 (2002).
[10]P. G. Kwiat, A. M. Steinberg, and R. Y. Chiao, Phys. Rev. A **45**, 7729 (1992).
[11]R. G. Ziefle, Phys. Essays **30**, 328 (2017).
[12]U. Sinha, C. Couteau, T. Jennewein, R. Laflamme, and G. Weihs, Science **329**, 418 (2010).
[13]Y. Zou, L. J. Wang, and L. Mandel, Phys. Rev. Lett. **67**, 318 (1991).
[14]J. Brooks, Int. Soc. Optics Photonics **7421**, 74210T (2009).
[15]A. Worsley, Phys. Essays **24**, 2 (2011).
[16]R. G. Ziefle, Phys. Essays **33**, 99 (2020).