Series: **PHYSICS**

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Photon structure

Annotation

The so-called. wave-AND-particle - WAP, which is a standing wave in the volume of a cube. On the sides of the cube, the flux is zero, i.e. the cube does not emit energy. However, there are magnetic and electrical strengths on the sides of the cube. It is shown that such HIV, having received a quantum of energy, becomes a quantum of energy flow and flies at the speed of light. Such a representation allows one to remove the contradictions between Maxwell's equations and the quantization of the energy of electromagnetic radiation, associated, firstly, with the fact that the energy transferred from light to atoms depends only on frequency, and, secondly, with the fact that it is impossible to find the wave equation for a photon.

Contents

1. Introduction

The photon has no mass and charge, has energy and momentum, flies only at the speed of light and exists only in flight. Nothing prevents him from flying and therefore he does not waste his energy in flight. But let me ask a childish question: "why does a photon fly?" It is not affected by the force of inertia and any external force. He has no desire to fly and he is not pursued by a sense of duty. Answering this question, which is indecent for a physicist, one has to assume that the driving force is inside the photon and does not give it rest.

We will consider the rationale for the possibility of the existence of a photon as a real particle (and not a virtual one)

2. Photon as a real particle

In [4, Chapter 4} a wave-AND-particle - WAP is described, which is a standing wave in the volume of a cube. This cube stores the flow of electromagnetic energy and pulses the internal flow of electromagnetic energy. On the sides of the cube, the flux is zero, i.e. the cube does not emit energy. However, there are magnetic and electrical tensions on the sides of the cube. More specifically, the size of the edge of a cube

$$L = \sqrt{\frac{3}{\mu\varepsilon}} 2\pi/\omega, \tag{1}$$

and strengths are defined as

$$E_x(x,y,z,t) = e_x \cos(\alpha x)\sin(\alpha y)\sin(\alpha z)\sin(\omega t), \tag{2}$$
$$E_y(x,y,z,t) = e_y \sin(\alpha x)\cos(\alpha y)\sin(\alpha z)\sin(\omega t), \tag{3}$$
$$E_z(x,y,z,t) = e_z \sin(\alpha x)\sin(\alpha y)\cos(\alpha z)\sin(\omega t), \tag{4}$$
$$H_x(x,y,z,t) = h_x \sin(\alpha x)\cos(\alpha y)\cos(\alpha z)\cos(\omega t), \tag{5}$$
$$H_y(x,y,z,t) = h_y \cos(\alpha x)\sin(\alpha y)\cos(\alpha z)\cos(\omega t), \tag{6}$$
$$H_z(x,y,z,t) = h_z \cos(\alpha x)\cos(\alpha y)\sin(\alpha z)\cos(\omega t), \tag{7}$$

where $e_x, e_y, e_z, h_x, h_y, h_z$ are constant amplitudes of functions; α, ω are constants. Wherein

$$e_y = e_x, \tag{8}$$
$$e_z = -2e_x, \tag{9}$$
$$h_x = -e_x\sqrt{\frac{3\varepsilon}{\mu}}, \tag{10}$$
$$h_y = -h_x, \tag{11}$$
$$h_z = 0, \tag{12}$$
$$\alpha = \omega\sqrt{\frac{\mu\varepsilon}{3}}. \tag{13}$$

Thus, the strengths are determined at the given e_x and ω. The inner energy of WAP

$$W_{\text{wap}} = \sigma \cdot e_x^2/\omega^3, \tag{14}$$

where

$$\sigma = 48\pi^6 3^{1.5}\varepsilon^{-0.5}\mu^{-1.5}. \tag{15}$$

Let WAP receive a quantum of energy from the outside

$$W_{\text{out}} = h\omega/2\pi, \tag{16}$$

гдe h is Planck's constant. At the same time, it becomes

$$W_{\text{wap}} = W_{\text{out}}. \tag{17}$$

From (15-17) we find the electrical strength in the energy quantum:

$$e_x^2 = \frac{h\omega^4}{2\pi\sigma} \tag{18}$$

For a vacuum at $h \approx 6.6 \cdot 10^{-27}$ we have:

$$\frac{h}{2\pi\sigma} \approx 4.4 \cdot 10^{-33}. \tag{19}$$

Moreover, from (18, 19) we obtain:

$$e_x = 0.14 \cdot 10^{-16}\omega^2. \tag{20}$$

We received the <u>electrical strength of WAP (as a quantum of energy), depending on the frequency</u>.

3. Photon and Maxwell's equations

The appendix considers the solution of the Maxwell system of equations for vacuum and shows that for a given amplitude of electric strength $e_x(x)$, and a given frequency, all the strengths of the electromagnetic wave and the density of the longitudinal flux of electromagnetic energy in the wave $S_z(x)$ can be found.

Consider the volume element of this electromagnetic wave. Strengths act in it, the flow of energy and it flies with a speed of c. Obviously, this volume is identical to the WAP-photon, which has an intensity $e_x(x)$ on one of its faces. <u>The mathematical description of such a photon is completely equivalent to the mathematical description of the wave as a whole</u>. Due to the legitimacy of Maxwell's equations, a longitudinal energy flux with the density $S_z(x)$ should arise, which carries the WAP-photon as a source of tension $e_x(x)$. Thus, the <u>WAP-photon, having received a quantum of energy, becomes a quantum of the energy flow.</u>

This energy flow exists in the vicinity of the WAP-photon (own energy flow circulates within the volume of the WAP-photon). Therefore, we will call this flow an <u>external</u> energy flow. This flow carries the energy of an electromagnetic wave, the density of which is determined by the Umov formula:

$$w_{wave}(r) = S(r)/c \tag{21}$$

As indicated, the photon received a quantum of energy W_{out}. This energy becomes the energy of a wave with a density $w_{wave}(r)$ in the vicinity of a photon with a radius R much larger than the size of a photon:

$$W_{\text{out}} = dz \int_0^{2\pi} \left(\int_0^R w_{wave}(r) \cdot dr \right) r \cdot d\varphi. \tag{22}$$

This energy is not consumed, because energy quantum cannot decrease. However, when a photon collides with an electron and at a frequency exceeding a certain value for a given material (the so-called red border of the photoelectric effect), the photon's energy can be transferred to the electron. Thus, the energy transmitted by a photon depends on its frequency, and does not depend on the energy density of the electromagnetic wave, i.e. the intensity of the wave carried by the photon.

Тем самым снято то противоречие между теорией Максвелла, по которой энергия световой волны должна зависеть только от её интенсивности (но не от частоты) и экспериментами, которые показывают обратное: переданная от света атомам энергия зависит только от частоты света, а не от интенсивности [2]. Объяснение состоит в том, что энергия фотонов, как квантов энергии, не расходуется при передаче энергии волны. Тем не менее, энергия фотонов равна энергии волны - см. (22).

4. Maxwell's equations and energy quantization

So, we have substantiated the existence of a photon as a real particle. But what prevents us from abandoning the concept of a photon as a wave?

The quantization of the energy of electromagnetic radiation has been proven by numerous experiments, and thus the existence of a photon, as a quantum of this energy, has been proved. But the existence of the photon was contrary to Maxwell's theory.

The first contradiction between was that the energy of a light wave depends only on its intensity, and the energy transferred from light to atoms depends only on the frequency of the light. waves Above we examined and removed this contradiction.

The second contradiction followed from the fact that there was a wave equation for electromagnetic waves, but it was impossible to find a wave equation for a photon and, as a consequence, it was impossible to represent the wave as a sum of photons [2]. "The solution to this problem was found within the framework of quantum electrodynamics" - as stated in [3].

The problem arose due to the fact that the wave equation was recognized as the only correct solution to the Maxwell system of equations, despite the fact that it violated the law of conservation of energy and other empirically established laws of electrical engineering. But it was so elegant that didn't want anything else! In fact, the Maxwell system of equations (as a system of partial differential equations) has many mathematical solutions, and among them - solutions that do not violate the laws of physics and do not contradict experiments. Such solutions are considered in [1] and, in particular, in the appendix. It is it that is represented there by formulas (1-14). In this regard, the above problem disappears. Thus, this contradiction is also removed.

Application

Consider the system of Maxwell's equations for vacuum, which has the form

$$\mathrm{rot}(E) + \frac{\mu}{c}\frac{\partial H}{\partial t} = 0, \tag{a}$$

$$\mathrm{rot}(H) - \frac{\varepsilon}{c}\frac{\partial E}{\partial t} = 0, \tag{b}$$

$$\mathrm{div}(E) = 0, \tag{c}$$

$$\mathrm{div}(H) = 0. \tag{d}$$

Consider the solution of this system of equations in the system of cylindrical coordinates r, φ, z. It was shown in [1] that this solution has the form:

$$H_r. = h_r(r)\mathrm{co}, \tag{1}$$

$$H_\varphi. = h_\varphi(r)\mathrm{si}, \tag{2}$$

$$H_z. = h_z(r)\mathrm{si}, \tag{3}$$

$$E_r. = e_r(r)\mathrm{si}, \tag{4}$$

$$E_\varphi. = e_\varphi(r)\mathrm{co}, \tag{5}$$

$$E_z. = e_z(r)\mathrm{co}, \tag{6}$$

$$\mathrm{co} = \cos(\alpha\varphi + \chi z + \omega t), \tag{7}$$

$$\mathrm{si} = \sin(\alpha\varphi + \chi z + \omega t), \tag{8}$$

where

$h(r), e(r)$ are some functions of the r coordinate r;

α, χ, ω are some constants.

In particular, in the absence of longitudinal stresses, we have:

$$h_z(r) = 0, \tag{9}$$

$$e_z(r) = 0, \tag{10}$$

$$e_r(r) = e_\varphi(r) = \frac{A}{2} r^{(\alpha-1)}, \tag{11}$$

$$h_\varphi(r) = -\sqrt{\frac{\varepsilon}{\mu}} e_r(r), \tag{12}$$

$$h_r(r) = \sqrt{\frac{\varepsilon}{\mu}} e_r(r), \tag{13}$$

$$\chi = \omega\sqrt{\mu\varepsilon}/c, \tag{14}$$

where A is some constant. In this solution, there is a density of the longitudinal flux of electromagnetic energy at a given radius

$$S_z(r) = \frac{\mathrm{c}}{4\pi}\sqrt{\frac{\varepsilon}{\mu}} e_r^2(r), \tag{15}$$

It is important to note that this energy flux does not change over time (in contrast to the well-known solution, where the energy flux pulsates, keeping its value only on average)

It was shown in [1] that the solution of Maxwell's equations in cylindrical coordinates and in rectangular coordinates for $\alpha \gg 1$ are equivalent in the sense that

$$E_x(x, y, z, t) = E_r(r, \varphi, z, t), \tag{16}$$

$$E_y(x, y, z, t) = E_\varphi(r, \varphi, z, t), \tag{17}$$

$$E_z(x, y, z, t) = E_z(r, \varphi, z, t), \tag{18}$$

$$H_x(x, y, z, t) = H_r(r, \varphi, z, t), \tag{19}$$

$$H_y(x, y, z, t) = H_\varphi(r, \varphi, z, t), \tag{20}$$

$$H_z(x, y, z, t) = H_z(r, \varphi, z, t), \tag{21}$$

где (x, y) и (r, φ) связаны уравнениями преобразования координат. Следовательно, полученное решение мы можем использовать, полагая $x = r$, $e_x(x) = e_r(r)$, $S_z(x) = S_z(r)$.

References

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