Series: **PHYSICS**

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On the nature of electric charge and static electric field

Annotation

First, it is shown that in the capacitor, which is included in the DC circuit, there is there is a flow of electromagnetic energy, which continues to circulate even after disconnecting from the DC voltage source, and even when the metal plates are removed. Taking this fact into account, further, by analogy with the wave-AND-particle (WAP), the field-AND-particle (FAP) is described, which can be an electric charge or a holder of a static field.

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1. Introduction

In [1] it is shown that in the capacitor included in the DC circuit there are both an **electromagnetic** field and flows of electromagnetic energy. It was also shown theoretically in [1] and experimentally in [2] that the flow of electromagnetic energy continues to circulate even after disconnecting from the DC voltage source. It remains even when the metal plates are removed, i.e. <u>energy is stored in the capacitor-dielectrics even in the absence of charges</u>. The energy contained in the capacitor (as potential energy) <u>represents electromagnetic energy stored in the capacitor in the form of a stationary flow</u>.

In [3], the wave-and-particle (WAP) is described as an alternative to the wave-particle in quantum mechanics, in contrast to which the WAP exhibits the properties of both waves and particles simultaneously (and not alternately, depending on the conditions interpreted in quantum mechanics). In [3], it is assumed that real elementary particles are WAP. WAP itself is a standing electromagnetic wave in the volume of a cube, which has no physical boundaries but retains its shape, volume, energy, mass, and momentum.

In particular, a photon is a WAP. An alternating electromagnetic field is carried by photons. For a static field, no real carrier particles (or "holders") of this field were found. In quantum mechanics, a virtual photon serves these purposes.

However, if we want to "close all questions" with real particles, then it is necessary to find (except for WAP) the holder of the static field. In addition, WAP cannot be an electrical charge because an alternating electromagnetic wave pulsates in it. Both of these functions are performed by the "construction" described below. This turns out to be possible if we take into account the fact noted above such as the existence of a stationary flow of electromagnetic energy in a capacitor disconnected from the voltage source.

2. Mathematical model of charge

Consider a cube-shaped capacitor and a solution to the **static** Maxwell equations similar to that proposed in [3] for other purposes. So, the strengths of the electric and magnetic fields found as a solution to Maxwell's equations have the following forms:

$$H_x(x,y,z,t) = h_x\cos(\alpha x)\sin(\alpha y)\sin(\alpha z), \tag{1}$$
$$H_y(x,y,z,t) = h_y\sin(\alpha x)\cos(\alpha y)\sin(\alpha z), \tag{2}$$
$$H_z(x,y,z,t) = h_z\sin(\alpha x)\sin(\alpha y)\cos(\alpha z), \tag{3}$$
$$E_x(x,y,z,t) = e_x\sin(\alpha x)\cos(\alpha y)\cos(\alpha z), \tag{4}$$
$$E_y(x,y,z,t) = e_y\cos(\alpha x)\sin(\alpha y)\cos(\alpha z), \tag{5}$$
$$E_z(x,y,z,t) = e_z\cos(\alpha x)\cos(\alpha y)\sin(\alpha z), \tag{6}$$

where $e_x, e_y, e_z, h_x, h_y, h_z$ are the constant amplitudes of the functions, α is some constant. The amplitudes are related by equations of the following forms:

$$h_z = 0, \tag{7}$$
$$h_y = -h_x, \tag{8}$$
$$h_x = -\frac{\varepsilon\omega}{\alpha}e_x, \tag{9}$$
$$e_y = e_x, \tag{10}$$
$$e_z = -2e_x \tag{11}$$

and can be determined for a fixed value of e_x. These equations describe a static field that exists in the volume of a cube whose edge has the following length:

$$L = \pi/\alpha. \tag{13}$$

The density of the electromagnetic energy of this wave is defined by

$$W = \varepsilon E^2 + \mu H^2. \tag{14}$$

Moreover, in this wave there is the following condition:

$$U = \varepsilon \left|E^2\right| = \mu \left|H^2\right|. \tag{15}$$

The total electromagnetic field energy in a cube is

$$W_o = U \cdot L^3. \tag{16}$$

The energy flux densities written by the corresponding coordinates' components are determined by the following formula:

$$S = \begin{bmatrix} S_x \\ S_y \\ S_z \end{bmatrix} = \begin{bmatrix} E_y H_z - E_z H_y \\ E_z H_x - E_x H_z \\ E_x H_y - E_y H_x \end{bmatrix}. \tag{17}$$

Consider the following formula:

$$\begin{bmatrix} \cancel{E_y} H_z - \cancel{E_z} H_y \\ \cancel{E_z} H_x - \cancel{E_x} H_z \\ \cancel{E_x} H_y - \cancel{E_y} H_x \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \tag{17a}$$

Notice that

$$\cos(\alpha x) = \cos\left(\alpha \frac{L}{2}\right) = \cos\left(\alpha \frac{\pi}{2\alpha}\right) = 0. \tag{17b}$$

Consequently, the strengths are vanish, which in the definition of functions (1)-(6) are cosine-dependent of some coordinate, on the face perpendicular to this coordinate. In formula (17a), those strengths are crossed out which depend on the cosine of the corresponding coordinate. It can be seen that the components in this formula are equal to zero. Therefore, the following conditions can be used on all faces of the cube:

$$\begin{bmatrix} E_y H_z - E_z H_y \\ E_z H_x - E_x H_z \\ E_x H_y - E_y H_x \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \tag{18}$$

i.e. **the cube does not emit energy**.

On each face of the cube there is an electrical field strength, the vector of which is perpendicular to this face. For instance, on a face perpendicular to the *x*-axis, vector (4) takes the value of

$$E_x \equiv \sin(\alpha x) = \sin\left(\alpha \frac{L}{2}\right) = \sin\left(\alpha \frac{\pi}{2\alpha}\right) = 1, \tag{19}$$

See also formula (13). So, the flow of energy does not leave this face but there is an electrical field strength perpendicular to this face. A similar conclusion can be made regarding the rest of the cube faces.

Figure 1 shows the electric field strengths coming out of the cube faces. On the faces with a negative sign, the strength coordinates are directed in the negative numbers' direction because $\sin(\alpha x)$=-1.

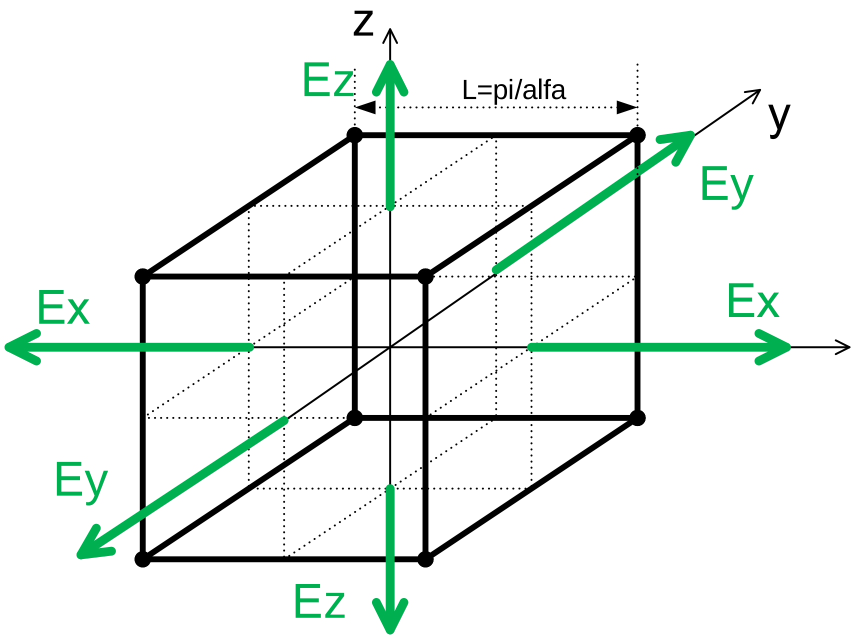

Fig. 1.

Let's take a look at figure 1. In front of us there is a cubic charge, on ALL faces of which there are electric field strengths of the same sign. Consequently, an electric charge is stored in a given cubic volume of an electromagnetic field. This charge can have any sign. If the vectors of electrical field strengths are directed outside the cube, then the charge has a positive sign. If they are directed inside the cube, then the charge has a negative sign.

Such a charge has much in common with the wave-AND-particle (WAP). It does not have any boundaries such as physical or formed by the inhomogeneity of the environment. It also has energy, an internal flow of electromagnetic energy (not going outside) as well as both momentum and mass as a consequence of the existence of this flow. Both the amount of energy and the strength of the external field are functions of the size of the cube only. In turn, the size of the charge is determined by both the size of the cube and the strength on the edges of the cube. Apparently, there is the smallest volume of the cube that can be determined by both the minimum energy quantum and the minimum charge. In what follows, we will call it the field-AND-particle (FAP). Let's find the following average electrical field strength on the surface of the FAP from (10) and (11), taking into account the uneven distribution of the strength along the face:

$$E \approx (e_y + e_x + e_z)/3 \approx e_x. \tag{20}$$

To determine the FAP charge, we represent it approximately as a ball with a diameter defined by expression (13) and use the following formula for the strength on the surface of the ball charge:

$$E = \frac{q}{4\pi\varepsilon_o r^2} \tag{21}$$

or, taking into account formulae (20) and (13) and the fact that $r = L/2$, the charge can be expressed as follows:

$$q = 4\pi\varepsilon_o \left(\frac{\pi}{2\alpha}\right)^2 E = \pi^3 \varepsilon_o e_x/\alpha^2. \tag{22}$$

3. The structure of the static electric field

FAP can be a part of particles. It can be assumed that the composition of the electron and proton includes the FAP.

However, the FAP can exist independently. A space filled with a multitude of FAPs, like a multitude of scattered electric charges, forms a static electric field. These FAP charges repel each other. What prevents them from scattering into infinity? Here we must remember that the FAP is a mass. The masses are attracted. Consequently, there is such a boundary of the electric field, where, for a given density of the FAP, the forces of their electrical repulsion and gravitational attraction are equal.

An extraneous electric charge caught in such an electric field will be pushed out by the field charges in one direction or another, depending on the sign of the field and the sign of the extraneous charge.

A foreign charge is a particle larger than the FAP field. When the signs of the field and the charge coincide, the charge is repelled from the set of FAPs and moves towards the weakened field.

When the signs of the field and the charge are opposite, the charge moves towards the enhanced field. At the same time, it is "pulled away" from those FAP charges, with which it has joined forces of attraction of opposite charges, towards a denser arrangement of FAP charges.

When moving through a field of charges that resists this movement, an extraneous charge, of course, changes mutual position of FAP but then the field charges return to their equilibrium state representing the state, in which the FAPs are distributed like repulsive electric charges. Therefore, it can be argued that the potential energy of an extraneous charge is the additional energy of an electric field, distorted by the presence of an extraneous charge and tending to pass into a normal state.

4. The appearance of a static electric field

As indicated, an alternating electromagnetic field is carried by photons, and no particles have been found for a static field. These particles can be called "holders" of this field. And this, it would seem, does not create problems. But in the general picture of electromagnetic fields, the absence of such particles violates the perfection of this picture. The FAP completes this picture.

It is clear that the static field appears when the disturbance of the alternating electromagnetic field stops. The tie of electromagnetic-field-to-the-electromagnetic-wave "freezes". In this state, it should turn into a standing wave, and the photons should turn into a resting particle. However, we first observe only an electric field or only a magnetic field and second, we do not see any particles. In addition, an electromagnetic wave cannot "freeze" in its entire volume at once and turn into a standing wave of a gigantic volume.

The FAP is perhaps what a photon turns into when a wave turns into a field. The process of transformation of an alternating electromagnetic field into a static field, as well as the process of disappearance of a static field, is not considered (simply because the author has nothing to say on this topic).

One can imagine such a picture. The charge moves and at the same time the photon dust scatters from it (“from under the wheels”) that flies at the speed of light as long as the charge moves. And then it settles where it flew and turns into motionless dust. Each photon (WAP) turns into a stationary FAP. For this, in the WAP cube, the electromagnetic wave must stop pulsing in time and "freeze" in a certain position. However, in this position, the energy flux, constant in magnitude, continues to move along a closed trajectory.

5. Coulomb's law

In our interpretation, an electrostatic field is a set of electric charges of the same name distributed in space by forces of mutual repulsion in accordance with Coulomb's law.

If the density of the distribution of charges of the FAP is known, then the distribution of the strength of the electric field created by these

FAP can be found. The inverse problem such as the determination of the density of the FAP distribution with a known distribution of the electric field strength can also be solved. Therefore, it can be argued that the natural distribution density of the FAP corresponds to the natural distribution of the electric field strength, i.e. it is determined by Coulomb's law.

Obviously, the interaction of charge 1 with charge 2 is equivalent to the interaction of charge 1 with the electric field of charge 2. Therefore, the field created by a set of FAPs under the influence of charge 2 is a medium that creates the Coulomb forces acting on charge 1. In other words, **an electric field, like the set of FAPs is the environment that implements the Coulomb law**.

This means that all interactions (including those discussed above) between electric charges are performed by a set of FAPs. Explaining these interactions does NOT need to involve the concept of long-range action.

It should be noted in this connection that the gravitational interaction is similar to the Coulomb interaction and a similar explanation can be found for it.

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