MODIFIED COULOMB LAW

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ABSTRACT

A field form of the Coulomb law is proposed, which describes the electric field as a function of the charge density gradient. This law is analogous in form to the modified Newton's law and similarly it reveals the possibility of attraction and repulsion of charges of the same sign as a function of the direction of the gradient of its density, and also the existence of electrostatic equilibrium. As an example of the use of this law, the erroneousness of the assertion that there are no free charges in the volume of the conductor is shown and a new treatment of the polarization processes is given as a result of the redistribution of charges of the same sign in it. A solution is proposed for the stability of atoms and their nuclei on the basis of electrostatic equilibrium and the wave concept of the structure of matter. Experimental confirmations of the proposed concept are presented.

Key words: electric charge, interaction, Coulomb and Newton laws, attraction and repulsion, equilibrium, polarization, dipole representation, unified field theory.

INTRODUCTION.

It is known since ancient times that the same bodies can acquire the property of electrifying both attracting and repelling them. This led to the idea of the existence of charges of different signs. The first scientists who argued this view were S. Dufet, who in 1733 introduced the terms "glass" and "resin" electricity, and B. Franklin, who renamed them in his book "Experiments and observations of electricity," published in 1749, into the positive and negative [1]. These ideas strengthened after Faraday's experiments with the separation of electrolytes into electrons and ions [2], the detection of positrons in cosmic rays [3], and the birth of electron-positron pairs [4]. A further extrapolation of these concepts was expressed in the concept of "supersymmetry", according to which each elementary particle has its own "antiparticle".

However, despite such wide generalizations, it is still unclear what the charge is at all, and thanks to which the electron differs from the positron. Moreover, recent experiments on the ASM (Alpha

Magnetic Spectrometer) program at the international space station [5] found that electrons and positrons are present in different cosmic ray fluxes, i.e. are born independently of each other. This result is consonant with the views of B. Franklin, according to which the difference in the sign of the same scalar quantity reflects only the excess or deficiency of some "electric fluid that can flow from one body to another during their contact." This position is confirmed in energy dynamics, as a theory that synthesized the methods of equilibrium [6] and nonequilibrium [7] thermodynamics and their generalization to nonthermal forms of energy [8]. According to the theorem proved in it, the number of energy arguments as a function of the state of any part (region, phase, component) of the system under investigation is equal to the number of non-independent processes occurring in it. This requires the uniqueness of the material carrier in any form of energy.

The question of the reason for the difference in the sign of the charge acquired a special sharpness in connection with the recent astronomical discoveries that led to the idea of the appearance of a baryonic (structured, observable) matter of the universe from non-baryon (unobservable) matter, which makes up at least 95% of the mass of the universe as a whole and participates only in the gravitational interaction [9, 10]. It became clear that all the observed elementary particles constituting the baryonic matter (protons, electrons, positrons, quarks, etc.) were formed as a result of the "condensation" of non-baryonic (unstructured) matter consisting of "dark" matter and "dark" energy and making up an invisible (hidden) part of the substance of the universe. One of the most productive concepts that explain the "mechanism" of the process of condensation of non-baryonic matter is the idea of formation of "closed waves" in the "primary" matter of the Universe, first expressed to the best of our knowledge by the astrophysicist Jeans [11] and supported by Schrodinger [12]. Their considerations, which form the basis of the concept of the wave nature of the structure of matter [13], allow us to present a consistent picture of the appearance of particles with opposite properties due to the difference in the spatial orientation of the closed traveling waves alone. However, for this it is necessary to show that the same closed waves in the internal structure as a model of the "particle" can cause forces of both attraction and repulsion depending on their position and distribution in space. In the case of particles of the same sign, which possess the only property-gravitational mass, this was done by modifying the law of gravitation of Newton [14].

The purpose of this article is to confirm the right to the existence of such a point of view for charges interacting according to Coulomb's law, thereby confirming the point of view of B.Franklin.

2. The field formulation of the Coulomb law

According to the law of S. Coulomb (1785), the Fe modulus of the interaction force Fe of two point charges q and Q is proportional to the product of the moduli of their charges q and Q, and inversely proportional to the square of the distance r between them [1]:

$$F_e = \frac{1}{4\pi\varepsilon_o} \cdot \frac{qQ}{r^2}, \qquad (1)$$

where εo is the dielectric constant of vacuum.

The Coulomb law corresponds to the potential of the electrostatic field φ (r) as a measure of its potential energy at the point of the field r at a distance r from the "field-forming" charge:

$$\varphi(\mathbf{r}) = \frac{1}{4\pi\varepsilon_o} \cdot \frac{Q}{r}. \tag{2}$$

This potential characterizes the weakening of the electric field with the distance from the center of the fixed "field-forming" charge Q and does not give the notion of a change in the electric field as a function of the charge density ρ_e in it $\varphi(\rho_e)$. Meanwhile, this is of fundamental importance, since the "reason" for the appearance of the force $\mathbf{F}_e = - (\partial U_e/\partial \mathbf{r})$ and the need to perform the work of W_e when moving a charge in an electric field $\mathbf{E}$ is precisely the inhomogeneity of the fields of electric charge density $\rho_e = \rho_e(\mathbf{r})$ and energy $U_e = U_e(\rho_e)$.

To see this, we select in space a sphere of unit volume V_0 with radius $r_o = const$ and charge density $\rho_e = Q/V$, on the surface of which the potential $\varphi(r_o)$ has the same value. According to the expression (2), this potential can be represented as:

$$\varphi(\rho_e) = (V_0/4\pi\varepsilon_0 r_0)\rho_e(\mathbf{r}). \tag{3}$$

In (3), the potential $\varphi(\rho)$ is represented as the implicit density function of the "test" (single) spheres $\varphi(\rho_e) = \varphi[\rho_e(\mathbf{r})]$, which allows to retain the meaning of the electrostatic field intensity $\mathbf{E}$ as a function of the field coordinate r and the negative gradient this potential. Taking into account the constancy of the expression in brackets (3), we have:

$$\mathbf{E} = - \nabla\varphi(\rho) = - (V_0/4\pi\varepsilon_0 r_0)\nabla\rho_e. \tag{4}$$

Adding the expression in parentheses to the value of the potential of the sphere of unit volume $\varphi_0 = \rho V_0/4\pi\varepsilon_0 r_0,$, we find:

$$\mathbf{E} = - \varphi_0\nabla\rho_e/\rho_e. \tag{5}$$

This is the desired "field" representation of the Coulomb law, which describes the field as a function of the density gradient of the charge $\nabla\rho_e$ distributed in it.
In contrast to the Poisson equation [1]

$$\nabla^2\varphi = 4\pi\varepsilon_0\rho_e, \tag{6}$$

expression (5) gives a direct relationship between the electric field and the local density of the "field-forming" charge ρ_e. This kind of "field" form of the Coulomb law is of interest primarily because it explicitly assumes the recognition of the inhomogeneous charge distribution in space, which was clearly the case in Coulomb's experiments. In this respect, it supplements the earlier theoretical conclusion of the Coulomb law, based on the inhomogeneity of the charge field [15].

Externally, expression (5) is completely identical to Newton's law in its alternative (field) form:

$$\mathbf{E}_g = - \psi_g\nabla\rho_g/\rho_g , \tag{7}$$

which expresses the intensity of the gravitational field $\mathbf{E}_g$ not through its potential ψg, but through the density $\rho_g,$, since the potential $\psi_g = c^2$ и $\nabla\psi_g = 0$ and [14] in accordance with the principles of equivalence of mass and energy $E = Mc^2$.

It is of fundamental importance that according to the laws (5) and (7), the electric field strength $\mathbf{E}$ and the gravitational field $\mathbf{E}_g$ can have a different sign depending on the direction of the gradient of the electric charge density or mass of matter. In other words, the recording of these laws in field form, when there are neither "field-forming" nor "trial" charges or masses, reveals in the fields of their density the presence of forces of attraction and repulsion of charges or masses of the same sign, depending on their distribution in space. This position in no way follows from the laws of Newton and Coulomb, which considered only the pair interaction of discrete masses or charges. It becomes

clear that the presence of a mass M or a charge Q is only a necessary condition for the existence of a gravitational field $\mathbf{E}_g$ and an electric field $\mathbf{E}$, whereas the difference from zero of the gradients of their densities $\nabla\rho_g$ and $\nabla\rho_e$ is its sufficient condition. This again emphasizes the difference between the concepts of the scalar $\rho_g(\mathbf{r})$, $\rho_e(\mathbf{r})$ and the vector (force) field $\nabla\rho_g(\mathbf{r})$, $\nabla\rho_e(\mathbf{r})$ of the field, the first of which is created by masses and charges, and the second - their inhomogeneous distribution in space.

It is equally important that these laws reveal the existence in the gravitational and electric fields of an unstable equilibrium, the condition of which is the vanishing of the density gradient of mass or charge:

$$\nabla\rho_g = 0 \; ; \; \nabla\rho_e = 0 \tag{8}$$

The existence of such an equilibrium and the possibility of existence of fields with a homogeneous distribution of masses and charges also did not follow from the laws of Newton and Coulomb, in which the forces of attraction or repulsion turned to zero only at infinity. This circumstance confirms the correctness of B. Franklin, who argued that the charge sign is determined by the excess or lack of density ρ_e "electricity" in space, and not inherent in it "from birth" as a feature of its structure or its "nature", i.e. to absolute, but relative. This radically changes existing ideas about the equilibrium distribution of masses and charges in space.

Let us consider some consequences of this circumstance.

3. Distribution of free charges in a conductor

According to the modified Coulomb law (5), the absence of an electric field $\mathbf{E}$ at ρ_e, $\varphi_0 \neq 0$ corresponds to an equilibrium (uniform) charge distribution ($\nabla\rho_e = 0$). A different conclusion follows from the Gauss theorem (1839), according to which for $\mathbf{E} = 0$ and $\rho_e = 0$ [1]. This means that there are no charges ρe inside the conductor, since there is no field in the conductor field $\mathbf{E}$, as is known even from the time of Franklin. Usually this is explained by the presence of Coulomb repulsive forces, which force free electrons to concentrate in the thin surface layer of the conductor, since "the presence of charges would certainly lead to the appearance of an electric field in it" [16]. This conclusion inevitably follows from the Gauss theorem. However, this theorem itself was based on the Coulomb law for a single point charge using geometric considerations and the notion of "field flow". Moreover, it was Coulomb's law that gave Gauss an idea of the "flow of the field" as an emanation "flowing" from the charge [1]. In reality, any field is similar to a terrain landscape that does not move anywhere at all, but only changes with time [17]. Moreover, such a representation is in flagrant contradiction with Ohm's law, according to which the electrical conductivity of a conductor is directly proportional to its cross section, and not to the perimeter along which current will flow in such a case. If this were the case, instead of solid wires in power lines, lighter tubular wires would have been used for a long time.

The inapplicability of abstractions of the "field flow" type becomes more obvious when considering heterogeneous (internally nonequilibrium) systems as an object of research [18]. Consider an arbitrary density distribution $\rho_i(\mathbf{r},t) = \partial\Theta_i/\partial V$ of some thermostatic quantity Θ_i (quantity of substance M, entropy S, charge Q, mole numbers of k-th substances N_k, their momenta $\mathbf{P}_k$, and moments $\mathbf{L}_k$, etc.), along the radius vector $\mathbf{r}$ at time t (Figure 1). As follows from the figure, if the distribution Θ_i, hereinafter referred to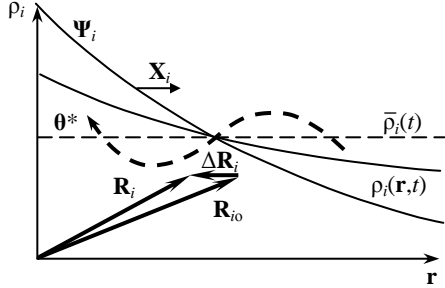 as the energy carrier for a short time, deviates from the uniform distribution with density $\bar{\rho}_i(t)$ certain amount of this quantity Θ_i* is transferred from one part of the system to another in the direction indicated by the arrow. This "redistribution" of the extensive quantity Θ_i (in this case, the density ρ_e of the charge Q) causes the center of this quantity to shift from the initial position of $\mathbf{R}_{io}$ to the current $\mathbf{R}_i$. It is known that the position of the center of some extensive quantity Θ_i, given by the radius vector $\mathbf{R}_i$, is determined by the expression:

Fig. 1. To the formation of the distribution moment.

$$\mathbf{R}_i = \Theta_i^{-1}\int\rho_i(\mathbf{r},t)\,\mathbf{r}\,dV, \quad \mathbf{R}_{io} = \int\bar{\rho}_i(t)\,\mathbf{r}\,dV, \tag{9}$$

where r is the traveling (Euler) spatial coordinate.

Comparing it with the position of $\mathbf{R}_{io}$ of the center of the same quantity Θ_i in the homogeneous state by density, we find that the deviation of the system from the homogeneous state is accompanied in this case by the displacement of its charge Q by the value $\Delta\mathbf{R}_e = \mathbf{R}_e - \mathbf{R}_{eo}$ and the occurrence of the "moment of distribution" $\mathbf{Z}_e$ of this quantity [18]:

$$\mathbf{Z}_e = Q\Delta\mathbf{R}_e = \int_V\left[\rho_e(\mathbf{r},t) - \bar{\rho}_e(t)\right]\mathbf{r}\,dV. \tag{10}$$

Thus, the removal of the system from the equilibrium state is accompanied by the appearance of additional degrees of freedom in it, associated with the displacement of the charge $\Delta\mathbf{R}_e$. This displacement generates a force $\mathbf{X}_e$ that tends to return the system to its original state:

$$\mathbf{X}_e = -(\partial U_e/\partial\mathbf{Z}_e). \tag{11}$$

The meaning of this force will become clear if one takes into account that the derivative (11) is in the conditions $Q = \text{const}$, when $d\mathbf{Z}_e = Qd\mathbf{R}_e$ and $d\mathbf{R}_e = d\mathbf{r}$, since it is measured in the same coordinate system. Thus, the $\mathbf{X}_e$ is the ordinary Coulomb force $\mathbf{F}_e = -(\partial U_e/\partial\mathbf{r})$, related to the transportable quantity Q, i.e. electric field strength $\mathbf{E}$. If the moment $\mathbf{Z}_e$ is attributed to the system of unit volume $\mathbf{Z}_{eV} = \rho_e\Delta\mathbf{R}_e$, as well as the electric displacement vector D, then it becomes obvious that $\mathbf{Z}_{eV}$ and $\mathbf{D}$ are equal in magnitude, since the divergence from both is equal to the charge density:

$$\text{div}(\mathbf{Z}_{eV}) = \text{div}\mathbf{D} = \rho_e. \tag{13}$$

However, the time $\mathbf{Z}_{eV}$ according to (9) differs from zero only for a nonuniform charge distribution, while the Gauss theorem certainly starts from the fact that the field $\mathbf{E}$ exists always when $\rho_e \neq 0$ (that is, excludes the uncertainty $\rho_e = 0/0$). Understanding this difference avoids the far-reaching conclusion that the electric field $\mathbf{E}$ is created by charges. In reality, the charges $\rho_e(\mathbf{r},t)$ create only a scalar field, understood by Feynman as a function of the distribution of any physical quantity in space, while the force field $\mathbf{E}$ according to (11) is determined by the negative gradient of this field, i.e. is generated by a nonuniform charge distribution in space, which follows directly from the expression for the force $\mathbf{F}_e = -(\partial U_e/\partial\mathbf{r})$ and leads to the well-known expression of the polarization work:

$$dW_{eV} = - dU_{eV} = \mathbf{E} \cdot d\mathbf{Z}_e = \mathbf{F}_e \cdot d\mathbf{r}. \tag{14}$$

Thus, the interpretation of the field $\mathbf{E}$ as an emanation that "runs away" from the charge as its source in the direction of the lines of force is far from harmless. The modified Coulomb law (5) allows us to correct these representations. According to him, the absence of the field E inside the conductor indicates only the uniform distribution of the charges in it, and not about their absence. When the conductor is introduced into the external electrostatic field $\mathbf{E}_o$, additional Coulomb forces begin to act on the charged particles, which cause displacement of the mainly free electrons inside the metal. As a result, in some areas of the conductor (and not only on its surfaces) there is an excess, and on others - the lack of density of free charge of one sign. In this case, an electric field of opposite intensity $\mathbf{E}$ arises, and at $\mathbf{E} + \mathbf{E}_o = 0$ the state of external equilibrium of the conductor and field is reached. Consequently, a conductor in an external field is characterized by an inhomogeneous distribution of electrons over the volume of the conductor, and not their absence.

4. Energodynamic interpretation of the polarization process

No less controversial is the assertion that the polarization of conductors in an external field is a consequence of the appearance of dissimilar charges on its opposite surfaces. It remains completely unclear where the unlike charges from free electrons originated, and how one can combine their displacement in a conductor with the assertion that there are no free charges in its volume.

The answer is obtained by applying the modified Coulomb law to the polarization process. This process is traditionally represented as the result of the emergence, from nowhere, of equal "associated" positive and negative charges, $\Theta e'$ $\Theta e''$ and $\Theta e''$, with their subsequent separation in space, and polarization of magnets in which the role of unlike charges is performed by even more mysterious "magnetic mass "or" pole ", which arise incomprehensibly again and again with each separation of a permanent magnet into parts. These dissimilar charges also arise in initially neutral dielectrics, sometimes this leads to the appearance of an excess charge of one sign. This phenomenon is "explained" by the extension of electric dipoles beyond the "boundaries" of the system, as if these boundaries are not fixed by the very notion of "system" as an object of investigation, and "cutting" of dipoles is not an artificial device [17] The same is true for the degree of their validity and the idea of the birth act of the "particle-antiparticle" pair from the physical vacuum.

In contrast, we want to show that polarization in the most general sense of this term consists in creating a spatial heterogeneity of the distribution of energy carriers of the same sign, although this process can easily be represented as the process of the formation of charges or poles of the opposite sign. To do this, it is sufficient to split expression (10) into two parts with volumes V', V'' and charges $Q' = \int(\rho e' - \overline{\rho}_i)\mathbf{r}dV'$, $Q'' = \int(\rho e'' - \overline{\rho}_i)\mathbf{r}dV''$, within which the charge density is greater and smaller than the average value ($\rho i' - \overline{\rho}_i > 0$ and $\rho i'' - \overline{\rho}_i < 0$). Since the system as a whole is electrically neutral, $Q'' = - Q'$, and instead of (10) we can write:

$$\mathbf{Z}_e = Q'\Delta\mathbf{R}_e' + Q''\Delta\mathbf{R}_e'' = Q''\Delta\mathbf{R}_e, \tag{12}$$

where $\Delta\mathbf{R}_e'$, $\Delta\mathbf{R}_e''$ are the displacements of centers of unlike (" polarization ") charges Q' and Q''; $\Delta\mathbf{R}_e$ $=\Delta\mathbf{R}_e' + \Delta\mathbf{R}_e''$ the dipole shoulder.

In a similar way, one can imagine both the dipole and momentum distribution of the ordered motion of the charges $\mathbf{J}_e = d\mathbf{Z}_e/dt$ (the so-called "molecular currents"), calling the components (12) opposite poles [8]. However, such an interpretation of the polarization process only removes us from reality, forcing us to seek an explanation for the processes of the birth and disappearance of the doubled number of charges or poles.

5. Electrostatic equilibrium as a condition for the stability of atoms

The establishment of the fact that the forces of electrostatic attraction or repulsion can occur in charges of the same sign, depending on their distribution in space, and on the existence of zones in which these forces vanish, introduces cardinal changes in the concepts of the structure of the atoms of matter and its stability. After Rutherford's discovery in 1911 of the atomic nucleus, the planetary model of the atom proposed by him was recognized. Since then, it has become generally accepted that the stability of the atoms of matter is ensured by the subtlest balance of gravitational forces of attraction of electrons to a positively charged core and centrifugal forces due to their orbital rotation. However, recent photos of atoms and crystal lattices, obtained with the help of tunnel scanning microscopes with a resolution of the order of several angstroms, do not even contain a hint of planetary arrangement of atoms. They indicate rather the presence of a so-called "elementary" particles of a complex internal structure [19]. This is also evidenced by recent experiments on scattering of electrons by obstacles, according to which they look as if they consist of concentric zones (bands) of elasticity, spaced from each other at a distance multipl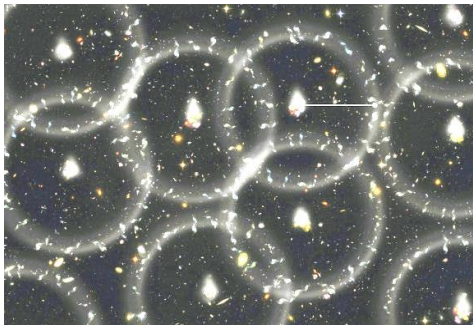e of the de Broglie wavelength [20]. This surprisingly coincides with the data of the Lawrence Laboratory in Berkeley (USA) on the distribution of clusters of galaxies (Fig. 2), recently obtained in the framework of the grandiose project of the digital sky survey (SDSS) [21]. Analyzing the distribution of celestial bodies at a fixed distance from the observer, scientists have found that galaxies are concentrated mainly either in its center or on the surface of the spheres at a distance from their center at a distance of about half a billion light years [22]. The researchers interpreted them as baryonic acoustic oscillations of the primary plasma of the universe [23]. This fully agrees with the above-mentioned wave model of

Fig.2. Spherical - wave structure of the
Universe
(Source: Berkeley National Laboratory)

atoms, according to which the forces of attraction and repulsion of any nature at the nodes and antinodes of the waves become zero [13].

Similar spherical waves were observed earlier in plasma [24], in ball lightning [25], in the ionosphere of the Earth [26] and in the form of "radio-mirrors" in distant cosmos [27]. All this emphasizes the unity of the gravitational and electrostatic spherical waves and gives grounds to believe that the "mechanism" of the stability of atoms does not consist in the subtlest balance of forces of different nature, but in more universal causes relating to nuclear forces. This is also due to the contradictory nature of the requirements for the properties of strong interaction, which should extend to very small distances (up to 10^{-13} cm), be replaced by repulsive forces with further removal of

nucleons and depend not on the magnitude of the charge, but on the mutual orientation of their spins). The wave structure of elementary particles, repeating the structure of the universe at the micro level, along with the fundamental unity of electrostatic and gravitational interaction, opens the possibility of a fundamentally different solution to this problem.

6. CONCLUSIONS

The modification of the Coulomb law made it possible to explain the distribution of electrons in the conductor and their electrical polarization, without resorting to the division of charges into positive and negative charges. This eliminates the fundamental difference between the electromagnetic interaction and the gravitational one and opens a direct path to the construction of a unified field theory that does not need to divide matter into matter and antimatter, particles and antiparticles, and consider electrostatic and electrokinetic (magnetic) energy as new degrees of freedom acquired condensation of a non-baryonic substance.

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