A compactified (almost popular) description of the unified fundamental interaction based on the Maxwell electromagnetism

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Preface

Why two particles electrically charged with the charges of opposite polarity attract each other and those charged with the charges of the same polarity are mutually repelent? Why is the gravity exclusively the attractive force? Why there is inertia of mass, but no inertia of electric charge? What is an intrinsic relationship between the electric and gravitational interaction? How can the structure of the atom be described within the theories of macroscosm as Maxwell theory of electromagnetism and/or general relativity? This five and several further fundamental questions are attempted to be answered by the authors of the most advanced physical theories. Here, we present an extract of the main results of our recent work [1] and [2], which addresses and answers these and several further questions in the case of the interaction between two stable (or accelerating from the rest), electrically charged, point-like particles. The work does not bring any principially new theory. It is a new, unitary representation of the well-known Maxwell theory of electromagnetism, completed with some formulas of general relativity.

The reader likely asks, why he or she should preferably devote his or her attention just to this work published among tens, maybe hundreds, other works published every year, which also address the above mentioned questions? After the Dirac's quantum theory, the unitary representation is only the second theory ever providing, in an independent way, the exact theoretical determination of the energy states in the spectrum of hydrogen atom (with the same precision as Dirac's theory provides). Moreover, one can hardly find another theory which would answer all the asked questions at the same time, within a single framework. The new representation remarkably applies the Occam's razor: to answer the questions, one can forget, in principle, the whole physics developed after Maxwell and Einstein, a major part of quantum physics including. The representation is, in fact, a continuation of the main-stream physics of the beginning of 20-th century. Of course, the value of the knowledge achieved in the post-Maxwell and post-Einstein era is not lost, a lot of mathematical procedures and partial concepts from the post eras is utilized also within the new approach.

1 Introduction to the new approach

To present our ideas, we consider, in the beginning, the simpliest system of two elementary, electrically charged particles (typically proton and electron), which are initially in rest, in a mutual distance r. The first particle is so-called "acting particle" (AP, hereinafter) and the second is "test particle" (TP). Into our concept, we accept the de Broglie's suggestion that each particles associates a wave with the angular frequency ω related to the particle's mass, m, as

$$\hbar\omega = mc^2, \tag{1}$$

where $\hbar$ is the Planck constant divided by 2π and c is the speed of light. However, this acceptation does not belong to the category of ad hoc initial assumptions (or axioms), but it appears to be a natural property of elementary particles in the context of Maxwellian electromagnetism, as we demonstrate below.

The basic feature of our description is the way of the calculation of the intensity of electric field, $\vec{E}$, generated by the TP at the presence of AP. This intensity is found by solving the Maxwell equations (MEs) in the old-new form

$$E_r = \pm i \frac{K_E}{r^2} \exp(\mp ikr) \exp(-i2\pi\omega t), \tag{2}$$

where i is the unit of imaginary numbers, K_E is an integration constant, k is the magnitude of wave vector, r is the radial distance of a given point of space from the TP, and t is time. The factor of 2π in the argument of the last exponential is inserted in purpose (see [1] or [2] for a detailed explanation of the reason). (In [1] and [2], a more sofisticated solution for E_r was given. In purpose of an easier explanation and understanding, we use the simple form (2), here.)

The time-dependent part in (2) can be re-written as $\exp(-i2\pi\omega t) = \cos(2\pi\omega t) - i\sin(2\pi\omega t)$. From the latter, one can "read" that there must be a wave in the environment (vacuum) around the TP, which spreads from a real-valued to an imaginary-valued space. As well, the particle must oscillate, because this behavior is also valid for $r \to 0$. In the complex space, its existence is, however, constant since the magnitude $|\exp(-i2\pi\omega t)| = 1$. The de Broglie's formula (1) is used to relate the wave characteristics (angular frequency) to the mass of the particle.

We note, there is no reason for the same phase of the oscillations of all particles in the universe. Instead we can expect that this phase is randomly distributed. Since we do not know the phase of given particle, there is an uncertainity in its occurrence in the observable real-valued (as well as unobservable imaginary-valued) space. The maximum of the uncertainity corresponds to the whole phase angle, 2π, and this implies equation $2\pi\omega t = 2\pi$. After we multiply this equation by $\hbar$, it changes to $\hbar\omega t = \hbar$ and realizing that the energy of the particle is $W = \hbar\omega = mc^2$, we obtain $Wt = \hbar$. The latter is one form of the Heisenberg uncertainity principle.

2 Mechanism of unified interaction

The waving center, which we further regard as a "core of particle", is obviously the source of the wave spreading from it and to it. The particle as a whole consists of its core and generated wave. Since it is reasonable to include the theory of relativity to the theory, we have to consider the wave which corresponds to this theory and this is an evanescent wave, as we demonstrate below. Such a wave caries an impulse. In more detail, when the wave leaves or impacts the TP, it delivers to this particle an impulse, which is, however, perfectly mutually compensated, because of the spherical symmetry. It has thus no net effect on the particle's dynamics.

The TP can become the object of a force action when the symmetry of its wave is broken. This can happen (1) *when another particle (AP) in a vicinity absorbs a fraction of the wave and its impulse* and this is the nature of **universal electric force**. And, (ii) *a force effect can also occur when the TP accelerates and, consequently, the blue-shifted-wave impulse in the acceleration direction is not completely compensated by the red-shifted-wave impulse from the opposite direction.* This is the nature of **inertia force**.

In the classical representation of the electric intensity, given by relation (2), this intensity is related to the corresponding force field, which influences the TP. Hence, intensity of E_r (the amplitude of its real-valued component) is regarded as the intensity related to the AP. This approach occurs to be problematic when we truly interpret the whole real-valued part of E_r, its time-dependent part including. The latter is proportional to $\cos(2\pi\omega t)$ and, therefore, not only the magnitude, but also the orientation of E_r changes with time. Such an oscillating field would cause only an oscillations of the TP around a mean position, but not a permanent one-direction force action, which is observed between the macroscopic electric charges.

As indicated above, we use the solution of the MEs (e.g. that given by relation (2)) to describe the wave generated by the TP itself and inspect the absorption of this wave by the AP, which causes the one-direction action on the TP. Because of this circumstance, the signal about the absorption of the TP-wave by the AP, i.e. about the "force action" on the TP, is mediated by the TP-wave, which is always moving with respect to the TP with the speed of light when the TP is in the rest in an inertial frame. We emphasize the invariability of this speed on the relative velocity between the TP and AP. This invariability corresponds to the postulate of special relativity about the same speed of light in every inertial coordinate frame. Our explanation of the reason for this postulate is, thus, simple and can even be comprehended by human imaginative power.

The magnitude and orientation of the acting (electric) force is proportional to the amplitude of E_r and the absorption factor, A, which is assumed to be also proportional to the amplitude in the distance $r = R_I$, where R_I is so-called interaction radius. It is related to the Planck's length l_P as $R_I = l_P/(2\pi\sqrt{\alpha})$, where α is the fine structure constant. It is useful to imagine (though it is not sure if this is the real picture) that each elementary particle (EP) acquires the form of full sphere with the varying radius during its oscillation period between the real-valued and imaginary-valued spaces, whereby the size of this radius varies from zero to R_I (in the moment of its maximum existence in the real-valued space).

For $r = R_I$ the third and higher terms of Taylor series of E_r-amplitude (2) can be neglected and, after a gauging,

$$A = \pm i + \frac{m_A}{M_o}, \tag{3}$$

where m_A is the mass of absorbing and, therefore, acting particle and M_o is formally established elementary electromass equal to $M_o = \sqrt{\alpha}M_P$ (M_P is the Planck's mass). Sign + (−) belongs to the positively (negatively) charged particle. The elementary electromass is established to formally replace the Coulomb law for two elementary charges by its Newton counterpart, i.e. its size is given by equality $q_o^2/(4\pi\varepsilon_o r^2) =$

GM_o^2/r^2. q_o is the elementary electric charge, ε_o is the permittivity of vacuum, and G is the gravitational constant.

The essential feature of the new representation is the derivation of the magnitude of wave vector, k, and understanding of its role in the description of the interaction. The quadrate of this quantity for the evanescent wave is

$$k^2 = \frac{\omega^2 - \omega_o^2}{c^2}, \tag{4}$$

where we define that ω is the angular frequency of the wave associated with the particle having energy, W, and ω_o is corresponds to the particle's rest energy, W_o. From this equation, we can obtain

$$\omega^2 = k^2c^2 + \omega_o^2. \tag{5}$$

According the well-known de Broglie relation, the wave vector, $\vec{k}$, and impulse, $\vec{p}$, are related as

$$\vec{p} = \hbar\vec{k}. \tag{6}$$

Using this relation and multiplying relation (5) by $\hbar^2$, we obtain from the latter the equation $\hbar^2\omega^2 = p^2c^2 + \hbar^2\omega_o^2$. Since $\hbar\omega = W$ and $\hbar\omega_o = W_o$, the last equation can be re-written to the form of the well-known relativistic equation for the energy of particle

$$W = \sqrt{p^2c^2 + W_o^2}, \tag{7}$$

where $p = |\vec{p}|$. However, as seen from the way of its derivation, this equation may not necessarily be represented, and further treated, as relativistic.

If the particle is situated in a force field, in which its potential energy is W_P, then the equation can be generalized to

$$W = \sqrt{p^2c^2 + W_o^2} + W_P. \tag{8}$$

At the same time, the angular frequency $\omega = \omega_o/\sqrt{1 + C_2/r}$ in the vacuum with the metrics described by the outer Schwarzschild solution. Multiplying the latter by $\hbar$ and considering the potential energy, we obtain that energy W of the particle can also be given by formula

$$W = W_o/\sqrt{1 + C_2/r} + W_P. \tag{9}$$

Using the relations mentioned in this paragraph, we can easily calculate k as the function of an integration constant C_2 figuring in the Schwarzschild solution and the function of potential energy. Specifically, the wave-vector magnitude can be given as

$$k = \frac{2\pi W_o}{\hbar}\sqrt{\frac{-\frac{W_P}{W_o}}{1 + \frac{W_P}{W_o}}}, \tag{10}$$

for a system of TP and AP, each consisting of only a single EP. W_P is the potential energy of TP in the the force field of AP and W_o is the rest energy of TP. In the new representation, W_P is whatever potential energy, i.e. not only the gravitational potential energy but the potential energy in an electric field can be supplied as well. For the Coulombian potential energy, ratio $|W_P/W_o| = |R_S/r|$, where R_S is the „generalized Schwarschild radius", distance separating two force regimes (described below).

3 Interaction in microcosm

Let us now consider the microscopic system of two particles, which consists of proton as the AP and electron as the TP.

The amplitude of the radial component E_r of the intensity, determining the magnitude and orientation of unified force, is

$$E_{or} = \frac{K_E}{r^2} \left[\pm i \cos(kr) + \sin(kr) \right]. \tag{11}$$

Again, sign $+$ $(-)$ belongs to the positively (negatively) charged particle. For the opposite polarities of TP (electron) and AP (proton) in hydrogen atom, we have $W_P/W_o = -R_S/r < 0$. According (10), k is the real-valued quantity in this case, when $r > R_S$. We note that $R_S = 2.8180 \times 10^{-15}$ m for the proton-electron system.

From relation (11) we can see that the intensity changes, with changing radial distance, r, not only its size, but also its orientation in both real-valued as well as imaginary-valued space. The particle, electron in particular, can be in the stable-equilibrium position, in the "force field" of proton, in such the distance from the latter, where the acting force is just zero and is repulsive (attractive) is the inner (outer) adjacent region.

In [1] and [2], it was shown that the force acting on the electron is proporional to $\sin(kr)$. So, it is zero and electron is in a stable-equilibrium position if $kr = 2\pi n$, where n is a natural number. Taking into account relation (10) with W_P and W_o given explicitly, the last equation is quadratic with the first solution giving the zero-force distances in which the energy of electron agrees with the measured energy terms of hydrogen atom corresponding to those in the Dirac's theory with the quantum numbers $l = n - 1$ and $j = l + /2$ (the full set can probably be found after giving solution also for the transversal components of the intensity vector and, possibly, using Kerr metrics to determine W and k).

The second solution of $kr = 2\pi n$ gives the zero force distances between R_S and $\approx R_S(1 + 1/\alpha^2)$ and this fact offers a posibility to explain the bounding of the particles in the atom nucleus. Such a concept is also supported by the fact that the free energy, $W - W_o$, of a particle rises above the corresponding Coulombian energy about the factor larger or equal than $1/\alpha$. The existence of zero-force distances implies the atom, in which its constituents do not move, but are bounded by the oscillating acting force in stable-equilibrium positions. Just two predicted regions of stable positions of electron correspond to just two observed counterparts.

For TP and AP with charges of the opposite polarity and $r < R_S$ (implying $1 + W_P/W_o < 0$) or for every r and TP and AP with the charges of the same polarity ($W_P > 0$), $k \to \pm i|k|$ according to (10). Therefore, the cosine and sine in (11) become hyperbolic cosine and hyperbolic sine which have no zero value for any $r > 0$. The acting force is monotonous, in this case. This behavior of the acting force between the TP and AP of the same polarity explains why there are no bound structures consisting of, e.g., two protons or two electrons.

4 Interaction in macrocosm

Our new representation of unique force action is almost completely based on the original Maxwell theory of electromagnetism. Equation (8) can also be regarded as a natural generalization of this theory for evanescent wave. One principial modification of the theory is, however, an alternative gauging of the integration constant C_2 for macroscopic objects. Namely, the radio C_2/r is defined as

$$\frac{C_2}{r} = \sum_{s=1}^{N_T} \sum_{j=1}^{N_A} \frac{W_{P(s,j)}}{W_{o(s)}}, \tag{12}$$

when we apply all relations containg constat C_2 to a point-like "test object" (TO) consisting of N_T electrically charged EPs and a point-like "acting object" (AO) consisting of N_A electrically charged EPs. The polarity of the charges of individual EPs is not constrained. In (12), $W_{P(s,j)}$ is the potential energy of s-th EP constituting the TO in the force field of j-th EP constituting the AO, and $W_{o(s)}$ is the rest energy of the s-th particle. The gauging (12) is assumed to be valid for the considered electric interaction despite the fact that the general relativity and Schwarzschild solution were assumed to be applicable only to the gravity.

We note, the potential instead of potential energy and c^2 instead the rest energy figure in the analog of relation (12) in general relativity. Replacing the potential and c^2 with the corresponding energies, one abandons, in fact, general relativity, because the equivalence principle is not longer. This principle cannot, however, be valid anyway in any theory of everything, since such a theory is expected to include also the quantum physics and the main equation in the latter is the Schrödinger equation, which also contains the potential energy instead of potential. Thus, the equivalence principle is largely violated in the quantum physics and, hence, must be invalid in the theory of everything.

However, the invalidation of equivalence principle in our new representation is not contradicting to observation. Namely, our replacement of the potential by potential energy invalidates the equaivalence principle in macroscopic phenomena *in principle*, but remains still valid, with a high accuracy, in practice. As shown in [1], the deviation from the general relativity equals the ration of $r/(2R_S)$ (distance R_S will be explained below). So, the deviation occurs at 33-th decimal digit, if we perform an experiment to prove or disprove the equivalence principle on the Earth's surface (on this surface, the dominant potential is that of the Sun, therefore the AO is the Sun and the TO is the Earth. Hence, $R_S \approx GM_\oplus M_\odot/(c^2 r_1)$ and $r_1/(2R_S) \approx r_1^2 m_p c^2/(2GM_\oplus M_\odot) \approx 2 \times 10^{-33}$, where $M_\oplus$, $M_\odot$, and m_p are the masses of the Earth, Sun, and proton, respectively, and r_1 is the Earth-Sun distance, i.e. one astronomical unit.)

If we consider the AO and TO, the intensity of unitary interaction is a superposition of partial interactions between all pairs of EPs, in which the first EP of the pair constitutes the AO and the second EP constitutes the TO. However, this superposition is not trivial and we outline the problems and the way to obtain the result at least for the point-like AO and TO.

Since the solution (2) predicts that the particles alone oscillate, whereby their phase shift can be from 0 to 2π, the acting force can vary from zero to a value larger than the average force. For a large number of particles, we can assume a random distribution of the phase shift and calculate the average force. In [1], we presented a simple model, which roughly (precision of $\sim$1%) describes the average force. It is proportional to $(1-2/\pi)/\pi$ multiple of the maximum force, occuring at zero phase shift, and the maximum force is proportional to the product of the amplitude of intensity, E_{or}, and absorption factor, A. The latter is the simple sum of the factors given by relation (3) for all EPs constituting the AO.

The macroscopic amplitude of intensity, E_{or}, is also a simple sum of the intensities of the force field generated by all EPs constituting the TO. However, the component of this sum is not given by relation (11), because radius R_S is extremely large for macroscopic objects (e.g., 3.53×10^{43} m on the Earth's surface, when the dominant potential of the Sun is considered; the AO is the Sun and TO is the Earth, in this case) and, thus, the common laboratory distances where the experiments use to take place are much shorter than R_S.

For $r \ll R_S$, we can approximate, with a high precision, that $k = 2\pi\omega_T/c$ (constant with respect to r, ω_T is the angular frequency of the wave associated with a given EP in the TO). The wave and approriate impulse is absorbed by an EP in AO in the distance r, but the effect of the absorption becomes efficient later, when the absorbed impulse is missing at the compensation of the impulse from the opposite direction in the distance $r = R_I$. So,

$$E_{or} = \frac{K_E}{r^2}\left(\pm i + \frac{m_T}{M_o}\right), \tag{13}$$

where m_T is the mass of the EP in the TO obtained after using the de Brogie's relation (1), i.e. $\hbar\omega_T = m_T c^2$ in this case.

If both, TO and AO are electrically charged, the second term in expressions for E_{or} and A can be neglected. Then, we transparently see why the orientation of electric force between the objects with charges of opposite polarity $(+i.(-i) = -i.(+i) = 1)$ is other than that between the objects with charges of the same polarity $(+i.(+i) = -i.(-i) = -1)$.

If we consider TO and AO consisting of the EPs with the same numbers of positive and negative charges, the first terms in the expressions for E_{or} and A can be eliminated. We achieve a ,,number neutrality". However, the objects possessing the number neutrality can never reach a perfect electrical neutrality, because the second terms are always positive and, thus, cannot eliminate each other. There always remains the "secondary" electric force proportional to $+m_T m_A/M_o^2$, i.e. oriented in the same direction as the force between two objects with charges of opposite polarity. If we identify $m_T \approx m_A \approx m_p$, the magnitude of the secondary force is of factor 10^{-36} lower than the primary force. Unless we do not wish having two gravities (that would contradict to observations), we must identify this aspect of the unified (or electric, since we solved the MEs) force to the gravity.

One can ask why we should accept the above outlined concept of the gravity, unified with the electric force, and reject the suggestions made within other hypotheses? We again emphasize that the same solution of MEs (only the scale of r is different) can also be used to calculate as macroscopic, gravitational or electrostatic, force as the energetic spectrum of the hydrogen atom. And, this ,,self-checking" exists only within the concept presented here.

5 Inertia and dimensionless equation of motion

The second term of E_{or} containing m_T and, therefore, ω_T can increase or decrease when the TP accelerates, because the angular frequency, ω_T, can be blue-shifted and red-shifted. Correspondingly, there occurs an excess of the impulse delivered to the TP at R_I. This excess is the nature of the **inertia force**. The first, ,,electric", term is constant, therefore there is no blue or red shift and, consequently, no inertia of electric charge.

The derivations of both acting and inertia forces use the solution (2). These mutually consistent derivations lead to the dimensionless, without physical units, equation of motion of the TO [1]. At the dawn of ages, people established the concept of mass and its unit to gain a possibility of mutual communication of every-day phenomena linked to the force by which our planet acts on things on its surface. After the electricity was discovered, the concept of electric charge was established in analogy with that of mass. The modern development of physics required an establishing of physical constants as the gravitational constant, permitivity of vacuum, or Planck's constant.

From the point of view of the unitary representation, these constants seem to be only the transformation constants between the artificially, by-humans established quantities, as mass and electric charge, and natural quantities as natural number, length, change of length, and the rate of this change. The unitary representation can avoid, in principle, any usage of these constants and artificial quantities.

6 A question at the end

In conclusion, the explanation of the basic fundametal properties of unique interaction as well as of the relationship between the macro and microcosm is unbelievably simple. So, why do we make the things difficult and hard, if we can have them simple?

References

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