AN ANALYSIS OF A POSSIBLE CORRELATION BETWEEN ELECTROMAGNETIC AND GRAVITATIONAL FORCES

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Abstract
The paper starts from the analysis of the actual justification of the separation existing between electromagnetic and gravitational forces. The existing justification is that the electrical dipole interaction force expression at distance $r$, depends on a principal term in $(r^{-4})$ and other terms with greater powers, while the gravitational force after Newton depends on $(r^{-2})$. In order to obtain the principal term in $(r^{-2})$, also for dipole interaction force, in the paper was sufficiently to complete the Coulomb law as a power series. With the corrected Coulomb law, for the electric dipole interaction force, an expression having the principal term in $(r^{-2})$, results. In the paper was made numerical checkings for the two formulae. The parallel numerical calculus showed a good agreement for the two forces. This result, if confirmed by other ways, will conduct at the possibility of detecting some reciprocal influences between actual gravitational field and electromagnetic fields.

1. OBSERVATIONS ABOUT GRAVITATIONAL AND ELECTRICAL INTERACTIONS

It is justified by the reality complexity and by a series of discrepancies between actual theories and experimental observations, to admit that it is unlikely that a complex reality may be perfectly described by a simple law, like Coulomb law for electrical forces (1) and Newton law for gravitational forces (2), (considering only scalar values in next developments):

\[ F_C = \frac{q_1 q_2}{4\pi \varepsilon_0 r^2} = \frac{k q_1 q_2}{\varepsilon_0 r^2} \text{; with } k=1/4\pi \] (1)

\[ F_N = -\frac{GMm}{r^2} \] (2)

More probable, for an accurate description of the complex reality, the most appropriate mode of description will be a long or infinite series of successive powers of the $r$ distance.

The above mentioned point of view, concerning the Coulomb law is confirmed by experiments, which allow to conclude that in the case of very short distances, (atomic) the law (1) is not precisely correct and in the case of long distances, it was not yet checked [1].

Concerning the Newton law, there are some deviations which were found in the trajectories of cosmic bodies, especially for large distances (comet movements, planet orbits etc.) [2] while for very short distances (atomic) the law couldn’t be precisely checked.

Despite the fact that bodies are neutral, the + and – charges are in fact always separated in space and consequently every charge + or – will exert its electrical interaction force $F_C$ to infinite distance according to (1). The electrical force $F_C$ may be calculated directly by (1) or indirectly by mediation of the electrical potential $\varphi$ and electrical field intensity $E$, both correlated by the equations [3]:

\[ E = -\text{grad } \varphi \text{ ; and} \] (3)

\[ F_C = q \cdot E \] (4)
**Fig. 1. Calculation of the force, produced by a dipole p**

Indirectly, the electrical potential $\phi$ in a M point of space, for a continuous distribution $\rho$ or for a discrete distribution of electric charges $q_i$ (Fig.1), will be:

$$\phi_M = \int \frac{\rho \, dV}{4\pi \varepsilon_0 r_i} = \sum_{i=1}^{n} \frac{q_i}{4\pi \varepsilon_0 r_i}$$  \hspace{1cm} (5)

Calculating the integral from (5) for $\phi$, a series of powers of $1/r$ is obtained [3]:

$$\phi_M = \frac{k_0}{\varepsilon_0 r^4} + \frac{k_1}{\varepsilon_0 r^2} + \frac{k_2}{\varepsilon_0 r^3} + \ldots$$  \hspace{1cm} (6)

In eq. (6), $k_i$ are charge moments about origin point and the behavior of $\phi$ at long distances will be given by the first non-null term. In the present it is accepted that macroscopic bodies have a random distribution of + and – charges, which will generate a random distribution of dipoles, in any direction, and all coefficients $k_j$ from (6) are canceled.

### 2. THE FORCE BETWEEN TWO DIPOLES, ADMITTING THE COULOMB LAW

By indirect calculation for the force $F_{Dx}$ upon a dipole, we will use the relation [3]:

$$F_{Dx} = p \cdot \text{grad}_x \cdot E_{Dx}$$  \hspace{1cm} (7)

From equation (6), the dipole potential is given mainly by the second term, resulting:

$$\phi^A_D = \frac{k_1}{\varepsilon_0 r^2} = \frac{p \cdot \bar{k}}{\varepsilon_0 r^2}$$  \hspace{1cm} (8)

where $k_1$ is a coefficient of measure units. The equation (7) may be rewritten using (3), for the force of a dipole in x direction upon another dipole, as:

$$F_{Dx}^B = p \cdot \text{grad}_x \left( -\text{grad}_x \phi^A_D \right) = -p \cdot \text{grad}_x \cdot \text{grad}_x \phi^A_D$$  \hspace{1cm} (9)

Introducing (8) in (9) we get:

$$F_{Dx}^B = -p \cdot \text{grad}_x \cdot \text{grad}_x \left( \frac{\bar{k} \cdot p}{\varepsilon_0 r^2} \right) = -\frac{p^2 \bar{k}}{\varepsilon_0 r^4} \cdot 6$$  \hspace{1cm} (10)

Note that the force $F_{Dx}^B$ of interaction between two dipoles, depends on the distance $r$ by a term in $r^{-4}$ if Coulomb law was admitted valid in (6).

### 3. THE CORRECTION OF COULOMB LAW

The force $F_{Dx}^B$ from (10) varying with $r^{-4}$ may be exerted at long distances $r$ without limits between any neutral electrically dipoles or bodies, as acts also the gravitational force between the same two bodies or dipoles, given by (2) but varying with $r^{-2}$.

At the same time, as is known the Coulomb equation (1) for electrical forces is not entirely valid for atomic or nuclear distances and was not confirmed for terrestrial and astronomical distances, were the weight of the term in $r^{-2}$ may not be absolute. Although the Newton law (2)
exhibit deviations from observed movements of astronomic bodies, but the term in $r^{-2}$ have the principal weight. Therefore, it seems logical to consider a general law for the forces $F_C$ and $F_N$ some series of powers in $r$.

So, in order to bring the expression from (10) closer to the form of Newton law from (2), we will introduce in (10) some terms of such a series, having also the term $r^{-2}$. We observe that this fact should be possible if we intervene in the primitive equation of $F_D$ from (10), which is the equation (6). But we observe that $\phi_M$ from equation (6) is deduced from Coulomb law from (1).

Therefore, it is necessary to intervene upon the Coulomb law (1), which must be corrected in the next general form by completing in both directions, the missing terms of the series in $1/r$ powers:

$$F_{CC} = -\frac{k_0 q q}{\varepsilon_0} \ln r + \frac{k_1 q q}{\varepsilon_0 r} + \frac{k_2 q q}{\varepsilon_0 r^2} + \frac{k_3 q q}{\varepsilon_0 r^3} + \frac{k_4 q q}{\varepsilon_0 r^4} + ..$$  \hspace{1cm} (11)

The intensity of electric field $E$ given by new Coulomb law corrected form (11) will be:

$$E_{CC} = -\frac{k_0 q}{\varepsilon_0} \ln r + \frac{k_1 q}{\varepsilon_0 r} + \frac{k_2 q}{\varepsilon_0 r^2} + \frac{k_3 q}{\varepsilon_0 r^3} + \frac{k_4 q}{\varepsilon_0 r^4} + ..$$  \hspace{1cm} (12)

In equations (11) and (12) the coefficients $k_i$ and $\varepsilon_0$ represent new constants, which should be determinate in order to obtain the best correspondence between experimental value for $F_{CC}$ or $E_{CC}$, and calculated values with (11) or (12).

The term of the form $\ln r$ gives an opposite sense for the electric force between two dipoles, compared to the sense of other terms of the form $1/r^n$. As a consequence, the sign – for the first term was introduced in (11) and (12) in order to obtain an attractive force (as the gravitational force) with (9) between the two dipoles, at large distances [4].

The first term in (11) will give between two charges + and - , at long distances, a repulsion force while between two charges + and + (or - and -), the force will be attraction.

We note that Eddington [5] obtained on the basis of his Fundamental theory a non–Coulombian energy of interaction. This is given by an exponential term, which gives an attractive force, between two protons situated at a distance of order of $5 \times 10^{-13}$ cm. Feynman [6] also sustains that the force between two protons is attractive for long distances, whereas, for small distances, is repulsive.

The other terms in (11) have at this moment only the role of completing the expression of $F_C$ from (1) with the missing powers of the infinite series. The term in $r^3$ may be identified with the primitive of Van der Waals forces, which at long distances are negligible.

4. DEDUCTION OF THE CORRECTED FORCE BETWEEN TWO FAR DIPOLES

In this case, we will use the equation (7). For direct calculation it is necessarily to establish the corrected electric field $E_{DC}$ of the dipole, from charge field $E_{CC}$ utilizing (12). This field will be determinate by applying the principle of effects superposition, for the dipole charges $+q$ and $-q$. If we note $r_n$ and $r_p$ the distances from the charges to the point M, (Fig.1), admitting for small $\Delta$: $r_p \approx r_n - \Delta$, and $ln[(r_n-\Delta)/r_n] \equiv (-\Delta/r_n)$ we get:
In (13), neglecting the term \( s \Delta \), \( \Delta^2 \), \( \Delta^3 \), ... relatively to \( r_n \), we obtain for large distances comparatively with dipole length \( l \):

\[
E_{DC} = \frac{k_0 q}{\varepsilon_0 r_n} - \frac{k_1 q}{\varepsilon_1 r_n^2} + \frac{k_2 q}{\varepsilon_0 r_n^3} + \frac{k_3 q}{\varepsilon_3 r_n^4} + \cdots
\]  

(14)

We can also write from Fig.1 when \( \theta \sim 0 \) (for oriented dipole in M direction):

\[
q \theta = q l \cos \theta \approx q l
\]  

(15)

Noting \( r_n = r \) for large distances, and introducing (15) in (14), results:

\[
E_{DC} = \frac{k_0 q}{\varepsilon_0 r} + \frac{k_1 q}{\varepsilon_1 r^2} + \frac{2k_2 q}{\varepsilon_2 r^3} + \frac{3k_3 q}{\varepsilon_3 r^4} + \cdots
\]  

(16)

The force \( F_{DC} \) on the \( x \) direction between two dipoles results introducing (16) in (7):

\[
F_{DCx} = p \cdot \nabla \cdot E_{DC} = \left[ \frac{k_0 q^2}{\varepsilon_0 r^3} + \frac{2k_2 q^2}{\varepsilon_2 r^4} + \frac{6k_2 q^2}{\varepsilon_2 r^4} + \frac{12k_3 q^2}{\varepsilon_3 r^5} + \cdots \right]
\]  

(17)

In (17) the first term in \( 1/r^2 \) is similar to Newton law from (2) and resulted from the term in \( \ln r \) from (11), which will give at long distances, a force which will be greater than that given by the other terms. In this case the polarization effect of each charge will be stronger than in Coulomb law, and it theoretically groves, increasing the \( r \) distance, but probably it develops discretely as quantum processes. Consequently, the atomic or nuclear polarization will take place at long distances between any two body, and the interaction force \( F_{DC} \) from (17) will act as the classical gravitational force \( F_N \).

We may expect that, at long distances, as planetary, the first term from (17) will have the principal weight, but we must admit that the rest of the terms from the series, may also have a non-null influence. But, at relatively short distances, atomic ones, the second or the rest of terms, must have an important weight. At very short distances, when \( \Delta \) is not negligible compared with \( r \), the relation (17) probably will be modified, and expression such as Van der Waals forces are so justified.

5. NUMERICAL VERIFICATION OF THE FORCE BETWEEN TWO FAR DIPOLES

In order to verify the \( F_{DC} \) force from (17) comparatively with \( F_N \) force from (2) was necessary to evaluate the coefficients \( k_i \) and \( \varepsilon_{0i} \) from (17). This was done from the condition to obtain the same result for \( F_C \) and \( F_{CC} \) from (1) and (11) considering two charges \( q_a \) and \( q_b \) each composed of \(+20e\) and \(-20e\) situated at a distance \( r=10^{-1} m \) resulting the following correction coefficients \( \rho_i \) [4]:

- for the 1st term... \( \rho_1 = 10^{-4} \); for the 2nd term... \( \rho_2 = 10^{-2} \)
- for the 3rd term... \( \rho_3 = (9.21-0.0101)/9.21=0.9989 \); for the 4th term... \( \rho_4 \approx 0 \)

The correct \( \rho_i \) coefficients must be experimentally determined.

Introducing (18) in (11) and reversing the signs in both members one got [4]:

\[
F_{CC} = -0.0000211*10^{-24} + 0.00921*10^{-24} + 0.91998*10^{-24} = 9.21*10^{-24} N = F_C
\]

For verification we will consider for simplicity, the dipole of an atom having \( N=40 \), and \( Z=20 \)
which means that it has 20 protons, 20 neutrons and 20 electrons.

The polarization distance $b$ between the + and – charge in the considered atom, have a subatomic order of magnitude. Accordingly to Purcell [5] for short range polarization, $b = 10^{-15} \text{ m}$ but for long range polarization we must take a shorter distance:

$$l = \frac{b}{10} = 10^{-16} \text{ m} \quad (20)$$

Introducing (19) in (17) for two selected atoms situated at $r$ distance it results:

$$F_{DC} = \frac{1.024 \times 10^{-57}}{4\pi \times 8.85 \times 10^{-12}} \left[ \frac{10^{-4}}{r^2} + \frac{2 \times 10^{-2}}{r^3} + \frac{0.9989 \times 6}{r^4} \right] = 0.9212 \times 10^{-57} \times |E| \quad (21)$$

Now we choose for verification, a planetary distance for $r$ when (2) is considered valid:

$$r = 100,000 \text{ km} = 10^8 \text{ m} \quad (22)$$

$$F_{DC} = 0.9212 \times 10^{-57} [10^{-20} + 2 \times 10^{-22} + 6 \times 10^{-24}] = 0.94 \times 10^{-77} \text{ N} \quad (23)$$

Now, we will calculate the gravitational force with Newton equation from (2), for the masses of same two dipoles of the same distance $r$ from (21), resulting (neglecting electron mass):

$$F_N = 2.3061 \times 10^{-77} \text{ N} \quad (24)$$

$$R = \frac{F_N}{F_{DC}} = 2.3061 / 0.9212 = 2.5 \quad (25)$$

The ratio $R$ remains the same, about 2.5 for greater $r$, as it is obvious from (21) and (2).

One remarks that the forces $F_N$ and $F_{DC}$ are practically equal for selected distance $r$ in (22).

Here we obtained the electric force $F_{DC}$ from electromagnetic constants, but equal with $F_N$.

For laboratory distance $r = 10 \text{ m}$, resulted:

$$F_{DC} = 60.39 \times 10^{-62} \text{ N} ; F_N = 0.23 \times 10^{-62} \text{ N} ; R = 0.0038 \quad (26)$$

For such short distances the results for $F_{DC}$ and $F_N$ in (26) differ more than in (24), still remaining of the same order, and the relative difference is indeed very small, of about $10^{-60}$. Maybe, for short distances must intervene other terms or new corrections for medium constant in (11) and in (17), or for $l$ in (20). We note here that $F_{CC}$ from (17) become null for a distance $r \approx 65 \text{ m}$.

6. CONCLUSIONS

In the paper was proposed a new expression for electrical forces. This formula gives for classic dipole interaction an expression of the same shape as the gravitational force. Was made numerical checking for the two expressions. In the expression for the electric dipole force was utilized the actual electromagnetic constants while in the Newton formula was introduced the gravitational constants. The parallel calculus showed a good agreement. So, for two atoms from the middle of elements table, situated at an astronomical distance, the two forces resulted practically of the same value, with the order of $10^{-77} \text{ N}$. This result, if confirmed by other ways, will conduct at a modification of electrodynamics laws and to the possibility of detecting some reciprocal influences between actual gravitational field and electromagnetic fields, including those utilized in transmissions.

References