

# Electrostatic Gravity Mechanism of Action Based On Dielectric Properties of Physical Vacuum and Physical Meaning of Gravitation Potential

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## To cite this article

Igor L. Misiucenko, Alexander K. Tomilin, Vladimir S. Vikulin. Electrostatic Gravity Mechanism of Action Based On Dielectric Properties of Physical Vacuum and Physical Meaning of Gravitation Potential. *American Journal of Modern Physics and Application*.

Vol. 3, No. 3, 2016, pp. 16-20.

**Received:** December 24, 2016; **Accepted:** February 4, 2017; **Published:** June 12, 2017

## Abstract

Connection between full gravitational potential and dielectric permeability of vacuum has been established. It has been shown that gradient of electric permeability of vacuum emerges near massive gravitating object. An attempt is made to explain gravitation mechanism on the basis of ponderomotive interaction of charged particles with anisotropic dielectric medium. Equivalency of gravitational mass and inertial mass has been proved within the frames of this approach. It has been shown numerically that light speed is determined by dimensions and mass of Universe.

## Keywords

Mass, Gravitational Potential, Dielectric Permeability of Vacuum, Gravitation, Physical Vacuum, Ponderomotive Force

## 1. Introduction

Gravity for many centuries is a mystery to humans. Since the time of Newton, there have been several successful mathematical theories of gravity, but there is no universally accepted theory that explains the physical mechanism of gravitation. This is the most significant gap in our knowledge of gravity. Currently physics doing research this problem in different directions: quantum theory of gravity based on the use of specific hypothetical particles-gravitons [9], theory based on the properties of hypothetical particles - quarks [8], theories, which is the development of general relativity [10], as well as various geometric and topological models [11].

As is well known [1], the basic idea of Einstein gravitational theory implies that all natural processes take place in space and time that correspond not to Euclid geometry, but to Riemann geometry. The space is considered to be absolutely empty, but its properties are inextricably connected with the distribution of gravitating masses and their motion. Deviations of geometric properties of space

from Euclid ones are explained by the presence of gravitating masses – i. e. masses determine the properties of space and time, and these exert influence on mass motion. Such a strictly mathematical approach enabled to obtain adequate result, which represents a basis for the General Relativity Theory (GRT).

However, the idea of empty space is interconnected with a number of fundamental problems and discordances. First of all it is in discord with the principle of close-range interaction. To eliminate this problem when considering interactions of material objects at each level (starting from quantum level and ending with the scale of Universe), one has to invent various agents of interaction – namely, fields, strings, virtual particles and the like.

There is no substance in absolute vacuum in the form of atoms and elementary particles that form atoms. However, vacuum still possesses certain physical properties inherent to matter. When using any system of physical units, dielectric and magnetic characteristics of vacuum are different from zero. Certain wave resistance is inherent to vacuum. Hence vacuum possesses known inductive and capacitance

properties. All this does not conform with notions about absolute emptiness. Therefore, a term “physical vacuum” has been used in quantum physics for a long time [2]. Physical vacuum is understood as continuous material medium formed by pairs of corresponding elementary particles and antiparticles. Hence dielectric properties are inherent to this material medium. This medium is a moving one, and flows, oscillations and stresses may occur in it. Therefore, it is impossible to apply an absolute reference system to this medium. It is just this circumstance that differs physical vacuum from ether, which was rejected in the course of relativity theory development.

An idea about development of physically profound gravitational theory follows from the above. Of course, results of this theory should be in agreement with known results of GRT, but with different interpretation – namely, without use of concepts about empty curved space.

The purpose of the present study consists in making an attempt to explain gravitation via electric interaction of substance and physical vacuum. The authors use results of article [3], which shows that mass is a purely electromagnetic phenomenon, while all mechanical phenomena are macroscopic manifestations of physical vacuum electro-dynamics.

## 2. New Gauge Fixing of Gravitational Potential

It is not difficult to derive an expression for free-fall acceleration on Earth surface and for the first and second cosmic velocities from the law of universal gravitation:

$$g = \frac{GM}{R^2}; \quad (1)$$

$$v_1 = \sqrt{\frac{GM}{R}}; \quad v_2 = \sqrt{2\frac{GM}{R}} \quad (2)$$

where  $G = 6,67408 \cdot 10^{-11} m^3 s^{-2} kg^{-1}$  - gravitation constant,  $M = 5,9 \cdot 10^{24} kg$  and  $R = 6,37 \cdot 10^6 m$  - mass and radius of the Earth, respectively.

Gravitational potential is normally used for description of gravitational field in classical mechanics. Gravitational potential has dimensionality of squared velocity and it is interpreted as a ratio of potential energy of material point located at distance  $r$  from the gravitating center to the mass of this point:

$$\Phi(r) = -\frac{GM}{r} \quad (3)$$

Gravitational potential on Earth surface is expressed via first and second cosmic velocities:

$$\Phi(R) = -\frac{GM}{R} = -\frac{v_2^2}{2} = -v_1^2$$

It should be pointed out here that scalar potentials are usually determined with accuracy to arbitrary constant. Therefore, full gravitational potential should be written down as follows:

$$\Phi(r) = -\frac{GM}{r} - C \quad (4)$$

where  $C$  – constant. Selection of specific value for this constant is called gauge fixing. Usually it is assumed that  $C = 0$ , in other words, it is believed that at infinity the gravitational potential is reset to zero. This is true if a gravitating body is considered to be a single body. However, all real space objects interact with one another and represent components of the Universe. Such an interpretation requires another gauge fixing.

Let's calculate the first cosmic velocity for the entire Universe considering the latter to be a globular formation:

$$v_{1U} = \sqrt{\frac{GM_U}{R_U}}, \quad (5)$$

where  $M_U, R_U$  - mass and radius of the Universe, respectively.

According to the present-day understanding, the age of the Universe is 13.8 billion light years. In this case its radius should not exceed 13.8 billion light years – i.e.  $1.3047 \cdot 10^{26} m$ . Currently the Universe mass is estimated within the range from  $6 \cdot 10^{52}$  to  $8.84 \cdot 10^{52} kg$  [5]. Taking the upper estimate of mass value from (8), we obtain:

$$v_{1U} = \sqrt{\frac{GM_U}{R_U}} = 2,12 \cdot 10^8 m/s$$

Taking into account a degree of approximation for the estimates of mass and dimensions of the Universe, the obtained value is quite close to the light speed. Hence, it turns out that the known light speed corresponds to the first universal cosmic velocity:

$$c_\infty = v_{1U} = \sqrt{\frac{GM_U}{R_U}} = 299\,792\,458 m/s$$

It is pertinent to note that we cannot apply the second cosmic velocity to the entire Universe because we have no idea of conditions of body motion beyond its borders. The postulate about limiting value of light speed within the Universe borders is not violated in the proposed theory.

The value of gravitational potential at the Universe border is assumed to be:

$$\Phi(R_U) = c_\infty^2 = 9 \cdot 10^{16} m^2/s^2$$

This value should be used as a gauging value. Full gravitational potential of any massive object is expressed in the following form with such a gauging system:

$$\Phi(r) = -\frac{GM}{r} - c_\infty^2 \quad (6)$$

By  $M$  is meant the mass enclosed in spherical volume with radius  $r$ . Full gravitational potential on the Earth surface is equal to the sum of squares of the first cosmic velocity of the Universe and first cosmic velocity of the Earth:

$$\Phi(R) = -\frac{GM}{R} - c_\infty^2 = -(v_1^2 + c_\infty^2) \quad (7)$$

Based on considerations of dimensionality, let's assume that dielectric permeability of space medium (physical vacuum) near gravitating bodies varies according to the law:

$$\epsilon_0(r) = -\frac{\xi}{\Phi(r)} \quad (8)$$

Coefficient  $\xi$  is to be determined. It is dimensionless in the Gaussian CGS system, while in SI system, it has dimension  $m/H$ . Sign «-» is necessary because gravitational potential  $\Phi$  is always negative.

Since dielectric permeability of space medium is connected with the light speed value, then it follows from the accepted hypothesis that light speed varies with the distance from gravitating object. The same result follows from the General Relativity Theory [1]. However, known astronomical data do not reveal significant difference between light speed  $c_\infty$  in remote regions of the Universe and  $c_R$  near the Earth [4]. Let's make an attempt to determine the difference between  $c_\infty$  and  $c_R$  within the framework of accepted hypothesis. It follows from (7) that the difference between them is equal to the first Earth's cosmic velocity:

$$c_\infty^2 - c_R^2 = v_1^2 = (7.9 \cdot 10^3 \text{ m/s})^2$$

From (8), taking the results obtained from (6) into account, we obtain a law for variation of dielectric permeability of vacuum depending on the distance to gravitating center  $r$ :

$$\epsilon_0(r) = \frac{\xi r}{c^2 r + GM} \quad (9)$$

In the strict sense, light speed should be viewed as function  $c=c(r)$ . Assuming that  $r \rightarrow \infty$  at the Universe border, we obtain the following:

$$\epsilon_0(\infty) = \frac{\xi}{c_\infty^2} \quad (10)$$

Here we omit a member with derivative  $dc/dr$  because (as shown above) the light speed gradient is small.

Since

$$c_\infty^2 = \frac{1}{\mu_0 \epsilon_0(\infty)} \quad (11)$$

then from (10) and (11), we derive:

$$\xi = \frac{1}{\mu_0} \quad (12)$$

In this case, (9) takes the following form:

$$\epsilon_0(r) = \frac{r}{\mu_0 (c^2 r + GM)} \quad (13)$$

On Earth surface:

$$\epsilon_0(R) = \frac{R}{\mu_0 (c_R^2 R + GM)} \quad (14)$$

Let's determine the difference between the values of dielectric permeability near Universe borders and near the Earth:

$$\epsilon_\infty - \epsilon_R = \frac{1}{\mu_0 c_\infty^2} - \frac{R}{\mu_0 (c_R^2 R + GM)} \approx 1.23 \cdot 10^{-20} \text{ F/m} \quad (15)$$

Relative variation of dielectric permeability of vacuum (i.e. dielectric permeability reduction) near the Earth will be:

$$\frac{\epsilon_\infty - \epsilon_R}{\epsilon_R} = 1,3 \cdot 10^{-9}$$

It is not easy to experimentally determine the difference between values of  $\epsilon_\infty$  and  $\epsilon_R$ . That is, dielectric permeability of vacuum medium is practically constant in the context of measurement accuracy (which can be attained at present). Nevertheless, dielectric permeability depends upon gravity (though this dependence is quite weak) and has non-zero gradient near massive bodies.

Thus, a new gauge fixing of gravitational potential has been proposed and substantiated by the authors of the present article. They have also established connection of gravitational potential with dielectric permeability of space medium near gravitating bodies. Besides that, this opens up possibilities for considering gravitational waves as a process of propagations of dielectric permeability disturbances in vacuum medium.

### 3. Electrostatic Gravitation Theory

Let's calculate a gradient of function (13):

$$\nabla \epsilon_0(r) = \frac{\partial \epsilon_0(r)}{\partial r} = \frac{GM}{\mu_0 (c^2 r + GM)^2} \quad (16)$$

In (16), like in expression (10) above, a member with derivative  $dc/dr$  has been omitted.

We have the following value on the Earth surface:

$$\nabla \varepsilon_0(R) = \frac{GM}{\mu_0 (c^2 R + GM)^2} = 0.96 \cdot 10^{-27} F / m^2 \quad (17)$$

Let's determine electrostatic force acting on electron in the vacuum medium, which we consider to be anisotropic dielectric. It has been known that anisotropic dielectric medium placed in an electrostatic field is subjected to an action of ponderomotive force [4], the volume density of which is determined by the following formula:

$$\mathbf{f} = -\frac{1}{2} E^2 \nabla \varepsilon \quad (18)$$

Strictly speaking, formula (18) is used only in the cases of linear dependence of dielectric permeability upon dielectric density [5]. This condition is fulfilled, for instance, in gases. Assume that vacuum medium anisotropy can be approximated by a linear function (at least, in the first approximation). It is just this case that is described below.

Our case is characterized by the opposite situation – a charge is located in an unbounded anisotropic dielectric medium. It is obvious that a force, with which the charge acts upon this medium, is equal (in modulus) to the force, with which the medium acts upon the charge. The signs of these forces are opposite. After integrating (18) in terms of volume  $\tau$ , we will calculate the force acting upon charged particle:

$$\mathbf{F} = \frac{1}{2} \int_{\tau_0}^{\infty} E^2 \nabla \varepsilon d\tau \quad (19)$$

where  $\tau_0$  - particle volume.

Formula (19) cannot be used for point particle. An electron model in the form of spherically shaped particle having clear boundaries is proposed in article [3]. It is thought that the electron is located in vacuum medium and is inextricably connected with the latter. Now we will place a frame of reference into electron center and origins of two coordinate systems – namely, Cartesian coordinates and spherical coordinate system. The linkage between Cartesian coordinates and spherical coordinates is set by the following relationships:

$$\begin{cases} x = r \cdot \cos \phi \cdot \sin \theta \\ y = r \cdot \sin \phi \cdot \sin \theta \\ z = r \cdot \cos \theta \end{cases}$$

Electric field of a particle is spherically symmetric in the selected frame of reference:

$$E = \frac{q}{4\pi \varepsilon_0 r^2} \quad (20)$$

Dielectric permeability of anisotropic medium can be presented in the form of linear function:

$$\varepsilon_0 = \varepsilon_0^{(0)} (1 + \eta \cdot z) = \varepsilon_0^{(0)} (1 + \eta \cdot r \cdot \cos \theta)$$

where  $\eta$  - is a certain constant parameter. This means that dielectric permeability in particle center is equal to  $\varepsilon_0^{(0)}$ , while function gradient  $\varepsilon(z)$  is directed by axis  $z$  and its absolute value is equal to:

$$\nabla_z \varepsilon(z) = \eta \cdot \varepsilon_0^{(0)} \quad (21)$$

After substituting (20) and (21) into (19), we can calculate the modulus of force acting upon the charge in the direction of gradient of dielectric permeability for medium:

$$F = \frac{q^2 \eta}{32\pi^2 \varepsilon_0^{(0)}} \int_0^{2\pi} \int_0^{\pi} \int_{\tau_0}^{\infty} \frac{\sin \theta d\phi d\theta dr}{(1 + \eta r \cos \theta)^2 r^2} = \frac{q^2 \eta}{8\pi \varepsilon_0^{(0)} r_0} \quad (22)$$

From (21), taking the results obtained from (17) into account, we can find a value of parameter  $\eta$  near the Earth surface:

$$\eta = \frac{\nabla \varepsilon_0(R)}{\varepsilon_0^{(0)}} = 1.09 \cdot 10^{-16} m^{-1} \quad (23)$$

Electron model proposed in [3] enabled to reveal purely electromagnetic nature of inertial mass and establish the connection between this inertial mass and electron charge:

$$m_0 = \frac{\mu_0 q^2}{8\pi r_0} \quad (24)$$

True (electromagnetic) radius of electron

$$r_0 = 1,4 \cdot 10^{-15} m$$

is two times less than classical electron radius, which (as is well-known) was determined in the particle-scattering experiment and corresponds to the size of effective electric field area. It should be pointed out that Lorentz has obtained almost the same value for free electron radius:  $r_0 = 1,5 \cdot 10^{-15} M$  [6].

Now we can determine the force (22) using inertial mass (24) and light speed near the Earth for this purpose:

$$F = \frac{q^2 \eta}{8\pi \varepsilon_0^{(0)} r_0} = \frac{m_0 \eta}{\varepsilon_0^{(0)} \mu_0} = \eta \cdot c_R^2 \cdot m_0 \quad (25)$$

After calculating the coefficient at  $m_0$  taking the value of parameter  $\eta$  from (23) into account, we can derive earth acceleration for free fall:

$$\eta \cdot c_R^2 = g = 9.81 m / s^2 \quad (26)$$

Hence:

$$F = \frac{q^2 \eta}{8\pi \varepsilon_0 r_0} = m_0 g \quad (27)$$

Thus, we have derived precise value for electron gravity

on Earth surface using inertial mass of electron for this purpose (24). Hence, the proposed theory identifies inertial mass with gravitational mass.

The cause of inertia, as have been shown in [3], consists in the interaction of charge with the flow of vacuum dielectric medium under the conditions of their relative accelerated motion. Origin of gravitation is explained similarly. Massive gravitating body interacts with a vacuum medium that surrounds the former. This results in the emergence of radial flows of vacuum medium with acceleration in the direction of gravitating center. Any body located on planet surface appears to be in the accelerated flow of vacuum medium. Gravitational force results from the interaction of elementary charged particles with dielectric vacuum medium.

It only remains for us to point out that atoms of a substance consist of three types of elementary particles. As is well known, electrons and protons possess elementary charge. Their masses are proportional to squares of their charges. Neutron is considered to be uncharged, but in free state it decays with the formation of electron, proton and antineutrino. Beside, it has been established experimentally that neutron has a charge structure [7]. Hence, neutron mass is proportional to the sum of squares of charges of its constituent particles (minus mass defect).

#### 4. Conclusion

Based on the obtained results, it's quite logical to come to the following conclusion – gravitation is an electrostatic phenomenon reflecting interaction of space electromagnetic medium with a substance. Results stemming from this theory agree with the General Relativity Theory results. The difference consists only in the interpretation of gravitation causes. The proposed theory is based on physical mechanism for interaction of two material objects – namely, elementary charged particle and physical vacuum.

Accelerated motion of dielectric vacuum medium in a chosen frame of reference is equivalent to the emergence of gradient of dielectric permeability of this medium, which results in the initiation of ponderomotive forces acting on the finite-size charges. The action of this mechanism is similar in both cases – in the case of inertia and in the case of gravity.

Since physical vacuum is thought to be a continuous medium, in which “flows” and “deformations” take place, it's obvious that it is impossible to select a single frame of reference and accept it as an absolute reference system. However, it is always possible to introduce and use a conditionally fixed “local” frame of reference, in which quite large volume of physical vacuum stays practically motionless at least in one of the directions. The state of local vacuum

medium depends on the presence of gravitating bodies. Besides, this state is described in a number of ways in different frames of reference. Due to this reason, light propagation speed depends on selection of frame of reference and varies in the vicinity of gravitating bodies. The time between events taking place in space medium depends on local speed of light. Hence, the clock rate depends on selection of frame of reference and presence of gravitating bodies. The difference in states of physical vacuum in GRT in different frames of reference is interpreted purely mathematically – as a distortion of space – time.

Development of physically profound theory of gravitation would enable to adequately describe and explain natural phenomena and find practical applications for them.

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