Journal of Theoretics

Journal Home Page

Magnetism as Manifestation of Gravitation

Jovan Djuric
Balkanska 28, 11000 Belgrade Serbia former Yugoslavia
oliverdj@eunet.yu

BRIEF SUMMARY

Using the point test mass and the defined point gravitational dipole, which together represent a very tiny rod-like non-magnetic object with the non-uniform mass distribution along its length, the interaction between the Earth and that suspended rod-like object on the surface of the Earth is analyzed by applying strictly the rules and the laws of the classical Newtonian mechanics. The center of self gravity of the Earth is used as the origin of the geophysical coordinate system for this calculation, not the center of mass of the Earth, which is the coordinate origin for the inadequate International Gravity Formula as this paper points out. It is shown that this experiment represents mathematically the gravitational dipole-dipole interaction between the intrinsic first mass dipole moment of the Earth and the intrinsic first mass dipole moment of the suspended test rod-like object. Defining the gravitational dipole distribution the paper shows that the large-scale Earth's magnetic field and its ferromagnetic regions can be consistently and logically accounted for as a manifestation of the Earth's gravitational field without any need for some electrical currents. This gravitational model of the Earth's magnetic field can easily and logically explain the disturbances and the variations of the Earth's ma gnetic field due to the Moon, the Sun, all the planets, the continental drift, the earthquakes and the reversal, as well as the climatic variations of the Earth, which are all the logical consequences of this model. The same gravitational model can be applied to all celestial bodies to explain their large-scale magnetic fields, including the solar cycle, which is caused mainly by the movement of the planet Jupiter with the lesser influences of the other much smaller planets. This gravitational model offers the logical explanation that some animal species are capable to detect the conventional Earth's magnetic field. It is emphasized that this mathematical model collapses totally and is not possible to be recognized, if the origin of the geophysical coordinate system is moved from the center of self gravity of the Earth to the center of mass of the Earth, which bears some resemblance to the heliocentric theory of Mikolaj Kopernik, since in the both cases, the correct choice of the proper coordinate system leads to truth and solution. Experiments are also discussed to prove experimentally this model or to disprove it with the consequential breakdown of the classical Newtonian mechanics, which is absurd from the logical point of view.

MAGNETISM AS MANIFESTATION OF GRAVITATION

by

Jovan Djuric

Balkanska 28, 11000 Belgrade, Serbia
former Yugoslavia
e-mail: oliverdj@eunet.yu

PACS: 03.50.Kk

BRIEF SUMMARY

Using the point test mass and the defined point gravitational dipole, which together represent a very tiny rod-like non-magnetic object with the non-uniform mass distribution along its length, the interaction between the Earth and that suspended rod-like object on the surface of the Earth is analyzed by applying strictly the rules and the laws of the classical Newtonian mechanics. The center of self gravity of the Earth is used as the origin of the geophysical coordinate system for this calculation, not the center of mass of the Earth, which is the coordinate origin for the inadequate International Gravity Formula as this paper points out. It is shown that this experiment represents mathematically the gravitational dipole-dipole interaction between the intrinsic first mass dipole moment of the Earth and the intrinsic first mass dipole moment of the suspended test rod-like object. Defining the gravitational dipole distribution the paper shows that the large-scale Earth's magnetic field and its ferromagnetic regions can be consistently and logically accounted for as a manifestation of the Earth's gravitational field without any need for some electrical currents. This gravitational model of the Earth's magnetic field can easily and logically explain the disturbances and the variations of the Earth's magnetic field due to the Moon, the Sun, all the planets, the continental drift, the earthquakes and the reversal, as well as the climatic variations of the Earth, which are all the logical consequences of this model. The same gravitational model can be applied to all celestial bodies to explain their large-scale magnetic fields, including the solar cycle, which is caused mainly by the movement of the planet Jupiter with the lesser influences of the other much smaller planets. This gravitational model offers the logical explanation that some animal species are capable to detect the conventional Earth's magnetic field. It is emphasized that this mathematical model collapses totally and is not possible to be recognized, if the origin of the geophysical coordinate system is moved from the center of self gravity of the Earth to the center of mass of the Earth, which bears some resemblance to the heliocentric theory of Mikolaj Kopernik, since in the both cases, the correct choice of the proper coordinate system leads to truth and solution. Experiments are also discussed to prove experimentally this model or to disprove it with the consequential breakdown of the classical Newtonian mechanics, which is absurd from the logical point of view.

INTRODUCTION

The large-scale Earth's magnetic field was recognized very long time ago and utilized for navigation for centuries, but its origin remains still a mystery. The Earth was considered to be a large permanent magnet, but that view had to be abandoned after the experiments in 1895 by Pierre Curie, see [1] and [2] for more details. The present day view is that the Earth's magnetic field is due to a dynamo action inside the Earth, see [2].

It is strange to realize that the gravitation was never attempted to account for the Earth's magnetic field. The explanation for this strange fact is that the two important points inside any celestial body, including the Earth, were never strictly distinguished, often erroneously interchanged and even considered as one single point, which is totally wrong. These two points are the center of self gravity and the center of mass. The center of self gravity is defined as the point inside the mass distribution of a celestial body at which the self gravity is zero. It is a unique point inside any mass distribution. The center of mass of a mass distribution is the point inside that mass distribution with respect to which the first mass dipole moment of that mass distribution is zero by definition. It is also a unique point under the same assumptions. It is easy to see that these two points never coincide for any real celestial body, unless that celestial body is perfectly symmetrical, which never occurs in nature. It will be shown that with these two points clearly distinguished and properly utilized, it is possible to form applying strictly the classical Newtonian mechanics a consistent, strict and logical model to account for the large-scale magnetic field and the regional ferromagnetism, if present, of any celestial body exclusively by gravitation without any need for the electrical currents, although they may be present especially in the case of the extremely hot celestial bodies like the Sun and the stars. Magnetism appears to be a manifestation of gravitation.

EARTH'S GRAVITATIONAL FIELD

The Earth's gravitational field is an old established subject dating back to Sir Isaac Newton, who in his famous Principia published in 1687 established the foundation of modern physics. The Earth's gravitational field in the accepted present day formalism and notation is the solution of the differential equation

$$\nabla \cdot \vec{g}_e = 4\pi G \rho_{me} \ , \qquad (1)$$

where ρ_{me} is the specified mass distribution per volume of the Earth, and G is the universal gravitational constant, whose value in the MKS system of units is $G = 6.67 \times 10^{-11} kg^{-1} m^3 s^{-2}$. By definition, the test point mass m experiences the force in the Earth's gravitational field $\vec{g}_e$ given by

$$\vec{F} = m\vec{a}\,' = -m\vec{g}_e \ , \qquad (2)$$

where $\vec{a}\,'$ is the acceleration of that point mass m with respect to the coordinate system which does not rotate with the Earth. Let $\vec{a}$ denote the acceleration of that test point mass in the coordinate system which rotates with the Earth with the constant angular velocity $\vec{\omega}$ with the common coordinate origin for both coordinate systems, then

$$m\vec{a} = -m\vec{g}_e - m\vec{\omega} \times (\vec{\omega} \times \vec{r}) - 2m\vec{\omega} \times \vec{v}, \qquad (3)$$

where $\vec{r}$ is the position vector of that test point mass and $\vec{v}$ is its velocity in that rotating coordinate system. The Equation (3) can be found in any comprehensive modern textbook of classical Newtonian mechanics. The second term in (3) is the centrifugal acceleration, while the third term is the Coriolis acceleration.

The solution of the Equation (1) for the specified mass distribution $\boldsymbol{r}_{me}$ at the point of observation defined by the position vector $\vec{r}$ is given by

$$\vec{g}_e = G\int \frac{\boldsymbol{r}_{me}(\vec{r}-\vec{r}\,')dV'}{|\vec{r}-\vec{r}\,'|^3} = -\nabla U_e \ . \tag{4}$$

The scalar gravitational potential U_e of the Earth is given by

$$U_e = G\int \frac{\boldsymbol{r}_{me}dV'}{|\vec{r}-\vec{r}\,'|} \ . \tag{5}$$

The point of observation as specified by the position vector $\vec{r}$ can be inside as well as outside the mass distribution, and the integrals in (4) and (5) are well defined under some very broad conditions.

For the point of observation outside the mass distribution, the potential U_e is now developed into the Taylor series

$$U_e = \frac{G}{|\vec{r}|}\int \boldsymbol{r}_{me}dV' + \frac{G}{|\vec{r}|^3}\int \vec{r}\cdot\vec{r}\,'\,\boldsymbol{r}_{me}dV' + \ldots \quad . \tag{6}$$

The total mass M_e of the Earth is

$$M_e = \int \boldsymbol{r}_{me}dV' \quad , \tag{7}$$

and $\vec{M}_{1e}$ is the first mass dipole moment of the Earth

$$\vec{M}_{1e} = \int \vec{r}\,'\,\boldsymbol{r}_{me}dV' \quad . \tag{8}$$

Retaining only the monopolar term and the dipolar term as the first approximation, the Equation (6) is written in the form

$$U_e = \frac{GM_e}{|\vec{r}|} + \frac{G\vec{M}_{1e}\cdot\vec{r}}{|\vec{r}|^3} = U_{0e} + U_{1e} \quad . \tag{9}$$

To repeat once more, all these expressions can be found in any comprehensive modern textbook of classical Newtonian mechanics and the potential theory.

There are obviously the two physically very important points for any mass distribution, including, of course, the Earth. Using the Equation (8) the center of mass of the Earth is defined by

$$\vec{r}_{cme} = \frac{1}{M_e}\int \vec{r}\,'\,\boldsymbol{r}_{me}dV' \quad , \tag{10}$$

where M_e is the total mass of the Earth given by (7). The other important point is the center of self gravity of the Earth, i.e., the point at which $\vec{g}_e$ given by (4) is equal to zero. Let $\vec{r}_{cge}$ be the position vector of the center of self gravity of the Earth, then by definition

$$\vec{g}_e(\vec{r}_{cge}) = G\int \frac{\boldsymbol{r}_{me}(\vec{r}_{cge}-\vec{r}\,')dV'}{|\vec{r}_{cge}-\vec{r}\,'|^3} = 0 \quad . \tag{11}$$

It is obvious from the definitions (10) and (11) that these two points can never coincide for the Earth, or any real celestial body, except in the case of the perfect symmetry of a celestial body, which never occurs in nature. Clearly, all above definitions can be applied to any material body.

The center of self gravity must be used as the natural coordinate origin in the calculation of the gravity in order to obtain the best approximation for the gravity, including the very important dipolar term. The first mass dipolar moment with respect to the center of self gravity is defined as the intrinsic first mass dipolar moment of the observed mass distribution. A body acts with its self gravity from its center of self gravity upon the center of mass of the other body as the first approximation. And vice versa, the other body reciprocates in the same manner upon the first body. There is a very important moment of force between the two gravitationally interacting bodies which is obvious, if those bodies are approximated as point masses and point intrinsic mass dipolar moments as the first approximation in the calculation of the gravitational interaction. A serious error is made if the center of mass is used as the origin of the coordinate system of reference in the calculation of the gravity. The dipolar term disappears as the consequence from the gravity expansion formula (9) by definition with the consequential serious error in the calculation from the point of view of the theory of approximation. Also, as the consequence, the body appears only as a point mass, thus loosing the character of a body. A celestial body, or any material body regardless of its size, is properly and best characterized and represented in the first approximation by its point mass, i.e., its total mass and its intrinsic point–like first mass dipolar moment, thus retaining the essential quality of a material body through its physically very important two centers of mass and self gravity. It must be emphasized that these two characteristic quantities of a mass distribution, i.e., its total mass and its intrinsic first mass dipolar moment are independent of the choice of the coordinate system. They are the two intrinsic invariants of a mass distribution, but obviously subject to variation if the mass distribution is varying.

INTERNATIONAL GRAVITY FORMULA

Using the experimental data about the Earth and assuming the center of mass as the origin of the coordinate system of reference, i.e., only the monopolar term is used as the consequence, the International Gravity Formula is obtained for the stationary test point mass, i.e., the Coriolis acceleration is dropped since the test point mass is at rest, in the following form (see [3], p. 79)

$$g = 9.780490(1 + 0.0052884\sin^2 \lambda - 0.0000059\sin^2 2\lambda) \quad m/s^2 \ , \tag{12}$$

where λ is the geographic latitude. The second term in the parenthesis is due to the rotation of the Earth, while the third term is assumed for fitting and has no physical meaning.

This Formula (12) does not show explicitly the dependence on r and φ, but the flattening $f^{-1} = 298.5$ must be used for the northern hemisphere, and the flattening $f^{-1} = 297.3$ for the southern hemisphere (see p. 79, [3]). This fact suggests that the dipolar term should be present in the correct Earth's gravity formula. The dipolar term is not present in the IGF (12), which is a serious error from the point of view of the theory of approximation in the numerical calculations, unless the center of mass and the center of self gravity of the Earth coincide, which is physically impossible in view of the fact that the real Earth is far from being perfectly symmetrical. Even the sea level, which is the reference for the IGF (12), is relative and questionable for the real Earth and subject to various changes.

So it is quite natural that the actual Earth's gravity measurements exhibit many noticeable deviations and anomalies with reference to the IGF (12), which is obviously inadequate.

GRAVITATIONAL DIPOLE-DIPOLE INTERACTION

The International Gravity Formula (12) is obviously inadequate, but it is not the purpose of this paper to propose a new Earth's gravity formula. That task should be undertaken only after many additional geophysical measurements. But this paper will show that the absence of the dipolar term in the Earth's gravity formulas so far, i.e., the erroneous and inappropriate choice of the center of mass of the Earth as the origin of the geophysical coordinate system of reference, and the error and the delusion about the center of mass and the center of self gravity of the Earth are responsible that an obvious mathematical model, namely, the gravitational dipole-dipole interaction was never conceived so far and considered and analyzed as a possible mathematical model based on gravitation to account for geomagnetism and planetary, solar and stellar large-scale magnetic fields.

The Equation (9), which is repeated here for convenience

$$U_e = \frac{GM_e}{|\vec{r}|} + \frac{G\vec{M}_{1e} \cdot \vec{r}}{|\vec{r}|^3} = U_{0e} + U_{1e} \tag{9}$$

is the first approximation for the potential of the Earth's gravity field, excluding the centrifugal and the Coriolis acceleration, for the observation points on the surface of the Earth and all outside points. This Equation (9) means that as the first approximation, the Earth's gravitational field is the superposition of the two gravitational fields, one due to a point mass monopole and the other due to a point mass dipole. The point mass dipole may be formally represented by two point masses, one positive and the other negative, which coincide with each other as the limiting case. This formal representation is not necessary. The only quantity which is important is the <u>intrinsic</u> first mass dipolar moment $\vec{M}_{1e}$ given by the Equation (8), which is calculated by definition with respect to the center of self gravity of the Earth.

The test object for the detection and the observation of the Earth's gravitational field as used so far from Galileo and Newton till the present days is a small sphere-like object, the legendary apple, small enough compared to the Earth to be considered as a point mass. That is how the point mass model came to be used on the Earth and within the planetary system as the presumably logical extension. But the Equation (9) shows unmistakably that the Earth's gravity is better approximated as a point mass and a point mass dipole. In order to preserve the consistency and logic, it is appropriate to define and to use as a test object for the observation of the Earth's gravitational field an object which is formally similar to the Earth, but very, very much smaller compared to the Earth, a point "Earth" so to speak of the molecular or even atomic size. That test object is defined by its point mass m, i.e., its total mass m, which is a scalar, and its point <u>intrinsic</u> mass dipolar moment $\vec{m}_1$, which is a vector by definition. But from the practical point of view, that test object is in reality, say, a very tiny rod-like or needle-like object whose non-magnetic mass is distributed non-uniformly along its length, so that for that test object its center of self gravity and its center of mass are clearly distinguished and defined with its intrinsic first mass dipolar moment $\vec{m}_1$ along its length strictly defined. Such a test object is especially very important to observe its interaction with the Earth's gravitational field, when that test object is suspended or pivoted at a point on the surface of the Earth.

Assume now that the above defined test object with its point mass m and its intrinsic first mass dipolar moment $\vec{m}_1$ is suspended on the surface of the Earth about its center of mass, so that it can rotate in the horizontal as well as the vertical plane. The point of suspension P_s is defined by the position vector $\vec{r}_s$ from the center of self gravity of the Earth. Thus the Earth's gravity is balanced by the contact force of the suspended system, but the rotation is freely possible. Friction is assumed to be negligible.

Let $\boldsymbol{r}_{m1}$ be the volume mass distribution of that test suspended object. By definition the torque exerted only by the Earth's gravitational field $\vec{g}_e = -\nabla U_e$, Equation (9) for U_e, is

$$\vec{T} = \int \vec{r}\,' \times (-\boldsymbol{r}_{m1} \vec{g}_e dV\,'), \tag{13}$$

where $\vec{r}\,'$ is the position vector of integration from the suspension point P_s. It is obvious that if $\vec{g}_e$ is uniform, so that it can be brought before the integral sign, the result is zero, i.e.

$$\vec{T} = \vec{g}_e \times \int \boldsymbol{r}_{m1} \vec{r}\,' dV\,' = 0 \tag{14}$$

in view of the assumption about the suspension point. The conclusion is that only due to the non-uniformity of $\vec{g}_e$ the torque (13) can yield a non-zero value.

Introducing the proper expressions for $\vec{g}_e = -\nabla U_e$, U_e given by (9), we obtain

$$\vec{T} = \int \boldsymbol{r}_{m1} \frac{GM_e(\vec{r}_s + \vec{r}\,') \times \vec{r}\,'}{\left|\vec{r}_s + \vec{r}\,'\right|^3} dV\,' - \int \boldsymbol{r}_{m1} \frac{G\vec{M}_{1e} \times \vec{r}\,'}{\left|\vec{r}_s + \vec{r}\,'\right|^3} dV\,' +$$

$$+ \int \boldsymbol{r}_{m1} \frac{3G[\vec{M}_{1e} \cdot (\vec{r}_s + \vec{r}\,')](\vec{r}_s + \vec{r}\,') \times \vec{r}\,'}{\left|\vec{r}_s + \vec{r}\,'\right|^5} dV\,' \quad ,$$

or, after some obvious simplifications and since $\left|\vec{r}_s\right| >> \left|\vec{r}\,'\right|$, approximately

$$\vec{T} \approx GM_e \vec{r}_s \times \int \frac{\vec{r}\,' \boldsymbol{r}_{m1} dV\,'}{\left|\vec{r}_s + \vec{r}\,'\right|^3} - G\vec{M}_{1e} \times \int \frac{\vec{r}\,' \boldsymbol{r}_{m1} dV\,'}{\left|\vec{r}_s + \vec{r}\,'\right|^3} + \tag{15}$$

$$+ 3G(\vec{M}_{1e} \cdot \vec{r}_s)\vec{r}_s \times \int \frac{\vec{r}\,' \boldsymbol{r}_{m1} dV\,'}{\left|\vec{r}_s + \vec{r}\,'\right|^5} \quad .$$

The suspended object was assumed to be rod-like, i.e., cylindrical with the axis well defined and its intrinsic first mass dipolar moment $\vec{m}_1$ directed along this axis. It is concluded that the two integrals in (15) must be the vector quantities along the same axis, i.e., proportional to $\vec{m}_1$, especially if the axial symmetry of that test object is assumed. Thus

$$\int \frac{\vec{r}\,'\rho_{m1}dV'}{\left|\vec{r}_s+\vec{r}\,'\right|^3}=k_3\vec{m}_1 \quad , \tag{16}$$

and

$$\int \frac{\vec{r}\,'\rho_{m1}dV'}{\left|\vec{r}_s+\vec{r}\,'\right|^5}=k_5\vec{m}_1 \quad , \tag{17}$$

where k_3 and k_5 are the scalar quantities which depend on the geometry of that test object and its non-homogeneous mass distribution. Hence

$$\vec{T}=GM_e k_3\vec{r}_s\times\vec{m}_1-Gk_3\vec{M}_{1e}\times\vec{m}_1+3Gk_5(\vec{M}_{1e}\cdot\vec{r}_s)\vec{r}_s\times\vec{m}_1 \quad . \tag{18}$$

This is an interesting result. Note that the vector $\vec{M}_{1e}$ generally has a component along $\vec{r}_s$, which is practically the vertical direction, as well as a component normal to that direction, i.e., in the horizontal plane. Thus, the torque (18) tends to align $\vec{m}_1$ with the vertical direction and also in the direction of the horizontal component of the vector $\vec{M}_{1e}$. The balancing direction of the vector $\vec{m}_1$, i.e., of the rod-like or needle-like suspended object, depends on many factors, but mainly on the position of the suspension point along that suspended rod-like object, since the center of mass, which is assumed to be the suspension point, may be very difficult to be determined in practice, i.e., always in the non-uniform gravitational field. Nevertheless, the suspended rod-like object with the non-homogeneous mass distribution along its length must assume an angle with respect to the vertical direction, and an angle measured in the horizontal plane from the North, which angle depends only on the vector $\vec{M}_{1e}$, which is, to repeat once more, the intrinsic first mass dipolar moment of the Earth. These angles may be referred to as the inclination and the declination respectively, to use the terminology associated with the magnetic compass. In view of the geophysical data, $\vec{M}_{1e}$ is directed from the southern to the northern hemisphere of the Earth. It must be determined experimentally.

In principle it is always possible to slightly move the suspension point and find such a point of suspension for which the first term, the third term and the appropriate portion of the second term in the Equation (18) cancel each other, which is written mathematically

$$\left\{GM_e k_3\vec{r}_s-Gk_3\vec{M}_{1ev}+3Gk_5(\vec{M}_{1e}\cdot\vec{r}_s)\vec{r}_s\right\}\times\vec{m}_1=0\ ,$$

i.e.,

$$M_e k_3\vec{r}_s-k_3\vec{M}_{1ev}+3k_5(\vec{M}_{1e}\cdot\vec{r}_s)\vec{r}_s=0\ , \tag{19}$$

where $\vec{M}_{1ev}$ is the vertical component of $\vec{M}_{1e}$.

Thus, the Equation (18) reduces to

$$\vec{T}=-Gk_3\vec{M}_{1eh}\times\vec{m}_1 \quad . \tag{20}$$

This formula (20) defines mathematically the gravitational dipole-dipole interaction subject to all above stated assumptions. Note that $\vec{M}_{1eh}$ is the horizontal component of the vector $\vec{M}_{1e}$. This gravitational dipole-dipole interaction has been derived applying strictly the laws and the rules of the classical Newtonian mechanics. This is mathematically identical to the magnetic needle in the conventional Earth's magnetic field. It must be emphasized that this mathematical model collapses totally and is not possible to be recognized, if the origin of the geophysical coordinate system is moved from the center of self gravity of the Earth to the center of mass of the Earth. Thus, it appears that this mathematical model bears some resemblance to the heliocentric theory of Mikolaj Kopernik, or of his forerunner and harbinger Aristarchos of Samos some 18 centuries earlier, since in the both cases, the correct choice of the proper coordinate system leads to truth and solution.

It is easy to show that the centrifugal acceleration $\vec{a}_c$ (the second term in the Equation (3)) does not exert a noticeable torque on the suspended rod-like object subject to all previous assumptions and approximations used in the derivation of (15). Namely,

$$\vec{T}_c = \int \vec{r}\,'\times \boldsymbol{r}_{m1}\vec{a}_c dV' = -\int \vec{r}\,'\times \boldsymbol{r}_{m1}\{\vec{\boldsymbol{w}}\times[\vec{\boldsymbol{w}}\times(\vec{r}_s+\vec{r}\,')]\}dV' \approx$$
$$\approx -|\vec{\boldsymbol{w}}|^2\, \vec{r}_s \times \int \boldsymbol{r}_{m1}\vec{r}\,'dV' + (\vec{\boldsymbol{w}}\cdot\vec{r}_s)\vec{\boldsymbol{w}}\times\int \vec{r}\,'\boldsymbol{r}_{m1}dV' \quad . \qquad (21)$$

This torque $\vec{T}_c$ is zero if the suspension point of the suspended rod-like object is at its center of mass as it was assumed. But when the suspension point is moved along the rod-like suspended test object, then this torque $\vec{T}_c$ must, in principle, modify somewhat the effect of the torque $\vec{T}$ (18), but by no means substantially, since the centrifugal acceleration due to the rotation of the Earth is only about 0.5 per cent of the Earth's gravity on the equator and zero on the poles. $\vec{\boldsymbol{w}}$ is the vector from the South to the North along the axis of rotation of the Earth by definition for the right-hand coordinate system, which is, roughly, also the general direction of $\vec{M}_{1e}$. The Coriolis acceleration is of no consequence, since the suspended test rod-like object is at rest when the balance is achieved.

The test rod-like object was introduced as an analogy to the Earth, a very tiny almost a point "Earth" so to speak with its point mass and its point mass dipolar moment. It is a fact that the mass distribution per volume $\boldsymbol{r}_{me}$ is not sufficient to define and describe the actual Earth at all its points. Some regions of the actual Earth are better described and defined as the conglomeration of the mass points, molecules or atoms, which are accompanied by the intrinsic point mass dipolar moments, which may be in some regions or domains aligned totally or partially, i.e., gravitationalized, or, shall we say, polarized or magnetized, which word was derived from the word magnet, i.e., the stone, a piece of the Earth from Magnesia, a region of Thesally in northern Greece, see Webster's Dictionary, College Edition. Designating by $\vec{M}_1$ the distribution of the intrinsic first mass dipolar moments per volume within a mass object, the gravitational potential due to such a distribution by generalization and analogy with U_{1e} in (9) is written in the form

$$U_d = G\int \frac{\vec{M}_1\cdot(\vec{r}-\vec{r}\,')dV'}{|\vec{r}-\vec{r}\,'|^3} \quad . \qquad (22)$$

It is obvious that this generalization introduces a new concept in the classical gravitational theory that various materials in nature are no longer defined only by their mass distribution functions, but also by their intrinsic mass dipolar moment distributions. Care must be taken to distinguish properly the macroscopic and the microscopic properties of the polarized or magnetized materials in order to fit the experimental data in the proper way. For instance, a rod may have the microscopic distribution of the mass dipolar moments, but it may also possess the macroscopic intrinsic dipolar mass moment, or it may be pivoted so to have the macroscopic mass moment with respect to the pivot point. The vector $\vec{M}_1$ in (22) is obviously defined with reference to the microscopic region. The analogy with the Earth's magnetic field is obvious. Note that $\vec{M}_1$ interacts only with the dipolar portion of the Earth's gravitational field in the case of the suspended or pivoted test rod. But obviously, if an object is falling freely in the Earth's gravitational field, it practically does not matter whether it possesses the microscopic mass dipolar moments or not, i.e., whether it is conventionally magnetized or not. The interaction with the Earth's magnetic field, i.e., the dipolar portion of the Earth's gravitational field according to this model, and of the magnetization of that falling object is practically negligible.

At the end of this paragraph the question must be asked and answered, why the effects of the torque given by (18), or (20) were never detected so far. The probable answer is that that torque (20) is very weak, and nobody was looking for it for reasons stated and discussed above in this paper. But that torque (20) must be present under the defined conditions, since otherwise, the classical Newtonian mechanics breaks down in this case, which is absurd from the logical point of view. The determination of the center of mass of the test rod-like object made of the non-homogeneous material in the non-uniform gravitational field is a very serious problem, whose exact solution may prove to be impossible. A pivoted needle made of the polarized or, shall we say, magnetized material, as such material was defined above, must certainly enhance the torque defined by (20), since that is a well-known magnetic compass needle, whose total first mass dipolar moment $\vec{M}_1 V_1$ interacts with the dipolar portion of the Earth's gravitational field in accordance with (20). V_1 is the volume of that needle whose $\vec{M}_1$ is assumed to be uniform along that needle. In that respect, it should be mentioned that the needle of an ordinary magnetic compass is slightly asymmetrical, with one leg slightly longer to offset the inevitable inclination by the obvious mass moment interacting with the Earth's gravitational field macroscopically with respect to the pivot point. This is essentially analogous to the mathematical condition of the Equation (19). Thus, it appears that the first intrinsic mass dipolar moment $\vec{M}_{1e}$ of the Earth multiplied by a suitable constant is the conventional Earth's magnetic dipole moment with some probably very minor influence, if any, of the Earth's angular velocity.

As the first approximation, the conventional Earth's magnetic field is $\vec{B}_{earth} = -\nabla U_{mage}$, where U_{mage} is the Earth's magnetic scalar potential given by (see [1])

$$U_{mage} = \frac{\mu_0}{4\pi} \frac{\vec{m} \cdot \vec{r}}{|\vec{r}|^3} \quad , \tag{23}$$

where $\vec{m}$ is the magnetic dipole moment of the Earth. From the above derived mathematical model it appears that that magnetic scalar potential of the Earth is, as the first approximation, directly proportional to the dipolar term U_{1e} of the Earth's gravitational potential given by the Equation (9) with the suitable constant of proportionality n_2 which must be determined experimentally. Thus,

$$n_2 U_{1e} = n_2 \frac{G\vec{M}_{1e} \cdot \vec{r}}{|\vec{r}|^3} = U_{mage} = \frac{\mu_0}{4\pi} \frac{\vec{m} \cdot \vec{r}}{|\vec{r}|^3} \quad . \tag{24}$$

According to the Equation (10), $\vec{M}_{1e} = \vec{r}_{cme} M_e$, where $\vec{r}_{cme}$ is the vector of the center of mass of the Earth with respect to the Earth's center of self gravity. Using numerical values for the Earth

$$M_e = 5.975 \times 10^{24} kg, \qquad |\vec{m}| = 8 \times 10^{23} Am^2 \quad ,$$

and the universal constants

$$G = 6.67 \times 10^{-11}\ kg^{-1} m^3 s^{-2} \text{ and } \mu_0 = 4\pi \times 10^{-7}\ H/m \quad ,$$

the Equation (24) yields

$$n_2 |\vec{r}_{cme}| \approx 20 \quad . \tag{25}$$

Both these two quantities n_2 and $|\vec{r}_{cme}|$ must be determined experimentally.

It must be emphasized that the above approximation of the conventional Earth's magnetic field by one singe term U_{1e} is very crude. Namely, the Earth's magnetic scalar potential given by (23) contains roughly the influence of the ferromagnetic materials on and inside the Earth, wherever present, while U_{1e} is obviously only global. In order to add the influence of the ferromagnetic materials on and inside the Earth, the additional term U_d as defined by (22) must be added to the main term U_{1e} with the integration for the experimentally measured and specified $\vec{M}_1$ throughout the Earth. But that should be the separate task and the subject for another paper after many additional geophysical measurements.

Hence, the above analysis shows unmistakably that an "elementary magnet", i.e., a portion of the magnetic domain of a highly complex, non-linear ferromagnetic material which even partially memorizes its previous state and the field to which it was subjected, appears to be properly definable as a point mass m with a intrinsic point mass dipolar moment $\vec{m}_1$, which, when suspended at the point defined by the position vector $\vec{r}$ on the surface in the Earth's gravitational field with its potential defined by the Equation (9), experiences a torque

$$\vec{T} = \vec{m}_1 \times (-\nabla U_{1e}) = -\vec{m}_1 \times \nabla \frac{G\vec{M}_{1e} \cdot \vec{r}}{|\vec{r}|^3} . \tag{26}$$

This is a generalization of the Equation (20). In fact, it should be considered as the definition of the interaction between the two gravitational intrinsic point dipoles in the situation as considered in this paper. Note that this Equation (26) defines the inclination, i.e., the interaction-rotation in the vertical plane, as well as the declination, i.e., the interaction-rotation in the horizontal plane, while the Equation (20) defines only the interaction-rotation in the horizontal plane. That means that for the "elementary magnet", the condition expressed by the Equation (19) must be somewhat modified together with the obligatory inclusion of the centrifugal acceleration, which may be rather important in this case of the rather small quantities involved in this Equation (19). The more detailed model of the "elementary magnet" remains as a subject of the future research. The expression (26) is essentially identical to the corresponding expression in the conventional theory of geomagnetism.

CONCLUSION

It is obvious that the above mathematical model of the gravitational dipole-dipole interaction, which was derived by the application only of the laws and the rules of the classical Newtonian mechanics, can be consistently applied to the Earth’s magnetic field, whose origin is still a mystery, cf. [1] and [2]. The natural magnet, which word magnet was derived from Magnesia, since it is a stone, i.e., a piece of the Earth from Magnesia, a district of Thessaly in northern Greece (see Webster's Dictionary, College Edition), appears to be an object with the distribution of the quite small internal portions, called domains, which consist of the almost point structures with the intrinsic first mass dipolar moments with, of course, the inevitable mass points. The density of gravitization or “magnetization” is $\vec{M}_1$, i.e., the volume distribution of the intrinsic first mass dipolar moments $\vec{m}_1$. Note that $\vec{M}_1$, in view of the Equation (24), must be multiplied by the constant $4\pi n_2 G/\mu_0$ to be converted dimensionally and numerically into the conventional magnetization density per volume as defined in the classical electromagnetic field theory. Thus, this mathematical - gravitational model fits consistently, logically and easily into the existing theory of magnetism, which should be somewhat modified by this model.

This mathematical model shows that the Earth’s magnetic field appears to be only a special manifestation of the Earth’s gravitational field with its essential dipolar term, but the angular velocity of the Earth may have some minor influence. Of course, the influence of ferromagnetism is defined by the density of gravitization or “magnetization” as stated earlier above. This model is consistent with all experimental facts about geomagnetism, cf. [1]. The variations due to the Moon, the Sun, the planets, the continental drift, the earthquakes and the reversal of the Earth’s magnetic field are the obvious straightforward consequences of this mathematical model. This model resolves completely and logically the enigma of the "missing magnetic monopoles", which turn out to be the ubiquitous mass monopoles. Also, this model eliminates totally the fictitious sheet-surface electrical currents associated with the permanent magnets by the conventional theory of magnetism. This model represents the true origin of the conventional Earth's magnetic field, or otherwise this model would represent the breakdown of the classical Newtonian mechanics.

The geological data show that the warm periods of the Earth with the melting of its polar ice caps were accompanied by the <u>increase</u> of the level of the oceans and the seas up to few meters - the floods as mentioned in the various legends, and by the <u>decrease</u> of the intensity of the conventional Earth's magnetic field, while the ice periods of the Earth were accompanied by the formation of the substantial polar ice caps with the <u>increase</u> of the intensity of the conventional Earth's magnetic field. These facts about those variations of the intensity of the conventional Earth's magnetic field are impossible to comprehend if the dynamo theory of the origin of the Earth's magnetic field is assumed. On the other hand, it is obvious that the melting of the Earth's polar ice caps with the increase of the ocean - see level must result in the decrease of the Earth's intrinsic dipolar mass moment, since the Earth becomes more spherical so to speak, and that means the decrease of the intensity of the Earth's magnetic field according to the mathematical-gravitational model as exposed in this paper, while the formation of the substantial Earth's polar ice caps during the ice ages - periods of the Earth must result in the increase of the intrinsic Earth's dipolar mass moment, i.e., in the increase of the intensity of the Earth's magnetic field according to this mathematical-gravitational model. The agreement of this model with the mentioned geological facts is obvious. The change of the Earth's warm and ice periods, i.e., the climatic variation of the Earth is presumably periodic and due to the variations of the direction of the Earth's axis of rotation according to the theory of Milankovic [4]. It appears at this moment that the Earth is approaching the warm period, but it is quite probable that due to the excessive fuel consumption of our civilization with the inevitable increase of the carbon dioxide, the warming of the Earth may be accelerated as the recent geophysical data about the increase of the temperature of Greenland indicate. Anyway, monitoring of the intensity of the Earth's magnetic field is obviously called for. The observed reported decrease of the intensity of the Earth's magnetic field of about 10-15 percent, see [5], is interpreted by some researchers as a beginning of the reversal of the Earth's magnetic field, and a cause for that reversal is as mysterious as the origin of that field so far. But according to the mathematical-gravitational model as developed in this paper, it appears that that decrease together with the floodings of many sand beaches as widely reported in newspapers and elsewhere are the signs of the approaching warm period of the Earth, and also possibly but not very probably the signs of the beginning of the reversal of the Earth's magnetic field, and both conclusions are in full accordance with this model.

It is concluded from this model that all celestial bodies, which are all somewhat asymmetrical due to the inevitable external gravitational fields, must possess the conventional large-scale magnetic fields with possible some regions of the enhanced magnetization, i.e., some regions of the distributed intrinsic first mass dipolar moments associated with the ferromagnetic materials. The planet Mercury should be mentioned particularly, since its magnetic dipole field detection and measurement by the Mariner 10 was unexpected and was a great surprise, see [6], but that magnetic field is quite natural and expected according to this model. The conventional large-scale magnetic fields of the celestial bodies are in the first approximation due to the intrinsic first mass dipolar moments with respect to their centers of self gravity. Of course, this model does not exclude in any way the electric currents as the additional sources of the magnetic field. This mathematical model only shows that the origin of the planetary magnetism as observed in the stones from Magnesia in northern Greece can be consistently and completely accounted for as the manifestation of gravitation without any reference to any electric currents which are obviously not observed macroscopically in the stones from Magnesia, i.e., the natural magnets.

As the immediate application and the check of this mathematical model, let us consider the Sun’s conventional large scale magnetic field whose magnetic dipole was observed to be practically normal to the axis of rotation of the Sun, i.e., practically within the ecliptic plane, see [7]. This fact is impossible to comprehend and account for by the assumed dynamo theory of the origin of that field. But the above mathematical model suggests that the Sun, essentially plasma, is stretched by the planets revolving around the Sun very approximately in the ecliptic plane and pulling the Sun's center of mass from the Sun's center of self gravity, thus creating the Sun's first intrinsic mass dipolar moment, i.e., the Sun's magnetic dipole as observed in the ecliptic plane and normal to the axis of rotation of the Sun. The dominant effect is due to the planet Jupiter, which is by far the largest planet, but the influences of the other planets cannot be neglected. The solar cycle of about 11 years of the Sun's spots is consequently largely determined by the planet Jupiter, whose period of revolution around the Sun is 11.86 years. This mathematical model appears to be reasonably in agreement with the observed facts about the solar cycle. This mathematical model can be also applied to the so-called non-Newtonian forces, which were observed and widely reported during 1980's, but more research is necessary.

The Earth's gravitational field inside the Earth and close to its center of self gravity is approximately the linear function of r and quite weak and of the order of $10^{-5}\ m/s^2$ or less at the distance of about $10\,m$ from the Earth's center of self gravity, assuming that the mass density in the core of the Earth is of the order of, or probably less than $10^5\ kg/m^3$, which is only a guess. Nevertheless, even such a very weak gravitational field, which acts against the internal elastic forces, may, in the long run, pull the center of mass towards the center of self gravity with the inevitable consequence for the Earth's magnetic field, which may change drastically and even pass through zero. However, in view of the fact that all the planets revolve around the Sun very approximately in the same ecliptic plane, which cannot possibly be a simple chance, it is reasonable to assume that there must be a component of a gravitational field from some very distant matter, say dark matter, etc. which is normal to the ecliptic plane and which keeps all the planets to revolve around the Sun very approximately in the same ecliptic plane. That same gravitational field together with the Earth's internal elastic forces can keep the Earth's center of mass away from the Earth's center of self gravity, thus keeping the Earth's magnetic field more or less constant, but always subject to some drifting and disturbances, which is a well-known fact and observed for centuries. It is also easy and tempting with this gravitational-mathematical model to visualize and to model the reversal of the Earth's conventional large scale magnetic field by and under some circumstances which depend on some causes outside our solar-planetary system from the very distant matter as our solar-planetary system is speeding through the Universe perhaps approaching that matter, but more research is obviously necessary. It must be emphasized that the Earth's magnetic field during the reversal passes through its reported interim phase with its interim magnetic dipole 90 degrees from its original direction just before the reversal, which is easily understood and modeled by this gravitational mathematical model. However, the reversal of the conventional Earth's magnetic field with its interim magnetic dipole 90 degrees from its original direction, i.e., normal to its original direction before the actual reversal, is almost impossible to comprehend, particularly the interim dipole, if the dynamo action is assumed as the origin of the conventional Earth's magnetic field.

This mathematical-gravitational model confirms completely the conclusions of many researchers, who although using quite different approaches and presumably the Schuster-Wilson-Blackett so-called "effect", found (see for instance [8]) that the cosmic magnetic fields pervade the Universe, just like the gravitational fields obviously do pervade the Universe, whose manifestations those cosmic magnetic fields certainly appear to be according to this model.

It is a well-known fact that some animal species, homing pigeons especially, some insects and some sea animals, are capable to detect the conventional Earth's magnetic field, which is easy to comprehend with this mathematical model. It appears that those animals, hovering and floating in their natural media air and water, thus mastering "the surly bonds of Earth" as a poet put it, i.e., mastering the Earth's gravity, are capable to detect even the minimal, slightest variations of the Earth's gravitational field.

APPENDIX ABOUT THE NECESSARY EXPERIMENTS

The Equation (20) defines the gravitational dipole-dipole interaction. It was derived by the strict application of the rules and the laws of the classical Newtonian mechanics using the geophysical coordinate system with its origin at the Earth's center of self gravity. That torque (20) cannot be recognized, if the origin of the geophysical coordinate system is moved to the center of mass of the Earth, in which coordinate system that torque (20) is zero by definition. Therefore, it is obvious that the experimental detection of that torque (20) and its measurement is absolutely necessary, but strictly with respect to the geophysical coordinate system with its origin at the center of self gravity of the Earth. Note that the absence of that torque (20) would mean the breakdown of the classical Newtonian mechanics, which is absurd from the logical point of view.

In order to obtain even a very rough estimate of the order of magnitude of that torque (20), it is assumed that the factor n_2 in the Equation (25) is equal to 1 (one) in the MKS system of units, so that $|\vec{r}_{cme}|$=20 m according to that Equation (25), which value appears to be reasonable. Since the numerical value of the Earth's magnetic field depending on location in the MKS system of units is about 5×10^{-5} T (0.5 Gauss), it follows from the Equation (24) that the order of magnitude of the horizontal component of the dipolar portion of the Earth's gravitational field is 5×10^{-5} m/s^2 =5 milliGals, with n_2=1 in the MKS system of units. On the other hand, the order of magnitude of the horizontal component of the dipolar portion of the Earth's gravitational field is approximately equal to 9.81 m/s^2 multiplied by $|\vec{r}_{cme}|/|\vec{r}_e|$, where $|\vec{r}_e|$=6.37×10^6 m is the so-called Earth's radius, which yields 3×10^{-5} m/s^2 =3 milliGals. This is the same order of magnitude as the above value obtained from the experimental value of the Earth's magnetic field.

Assume now that the rod-like or needle-like test object as defined in this paper is 0.1 m in length with the copper mass of 0.01 kg non-uniformly distributed along its length. The estimated obtainable intrinsic first mass dipolar moment of that test object $|\vec{m}_1|$ is of the order of 10^{-4} kgm. Hence, the estimated value of the torque defined by the Equation (20) is of the order of 3×10^{-9} Nm, or thereabouts. Of course, the quantity $|Gk_3\vec{M}_{1eh}|$ in that Equation (20) is the horizontal component of the dipolar portion of the Earth's gravitational field by definition with its estimated value quoted above. This estimated value of the torque is very small, whose detection and measurement with respect to the direction of the Earth's self gravity center is a very serious task, complicated even more by the inevitable friction in the suspension system or the pivot system. It is obvious that the increase of the mass and the length of that test object may be helpful to offset friction, but there is a limit in that approach. The locations for such experiments should be a number of different flat land sites around the Earth sufficiently far away from any ferromagnetic substances, any mountains, any buildings and other tall objects, including trees in order to avoid the possible interference of any horizontal components of the gravitational fields of the mentioned objects. These experiments will have to prove the existence of the torque (20), or its nonexistence with the consequential breakdown of the classical Newtonian mechanics, which is, to repeat once more, absurd from the logical point of view.

The preliminary but inadequate experiments by this author in his apartment in a high-rise apartment building just below the Terazije plateau in the center of old Belgrade do corroborate the existence of the torque given by the Equation (20), but the strictly supervised experiments as outlined above are absolutely necessary.

REFERENCES

1. Chapman, S. and Bartels, J., Geomagnetism, Vols. I and II, 2nd Edition, Oxford University Press, London, England, 1951.
2. Rikitake, T., Electromagnetism and Earth's Interior, Elsevier Publishing Company, Amsterdam, Netherlands, 1966.
3. Heiskanen, W. A. and Moritz, H., Physical Geodesy, W. H. Freeman and Company, San Francisco, California, U.S.A., 1967.
4. Milankovic, M., Kanon der Erdbestrahlung und seine Anwendung auf das Eiszeitenproblem, Serbian Academy of Sciences, Belgrade, Serbia, 1941.
5. Broad , W.J., As Earth's Magnetic Field Weakens, Compasses May Point South, Science and Technology Page, The New York Times, July 25 and July 26, 2004; also published simultaneously in English by Le Monde, Paris, France, July 25 and July 26, 2004.
6.Sagan, C., The Solar System, Scientific American, Vol. 233:3, pp. 23-31, 1975.
7. Wilcox, J. M. and Gonzalez, W., A Rotating Solar Magnetic "Dipole" Observed from 1926 to 1968, Science, Vol. 174, pp. 820-821, 1971.
8. Opher, R. and Wichoski, U. F., Origin of Magnetic Fields in the Universe due to Nonminimal Gravitational-Electromagnetic Coupling, Physical Review Letters, Vol. 78, pp. 787-790, 1997.