

EARTH'S ROLE AS A GENERATOR OF ELECTRICITY

Vasile Turcu

515800-Sebes, str. M. Eminescu 30, Alba, Romania, E.U.

vturcu1@yahoo.com

Abstract. I shall define the magnetic field and the equivalence between a body's mass and its electric charge. On this basis, the mass of the Earth's core shall be theoretically calculated, and shall result in a value that corresponds to established findings. The Earth is like a magneto, of which its rotor behaves like an alternator. The inner and outer cores rotate in opposite directions to each other, with the inner core behaving like an inductor and the outer core being induced. Then I shall obtain the electric charge, the force of electric fields and the electric potential at the Earth's surface. Throughout, I shall be applying some theoretical propositions to the concept of Earth's electrical energy. I shall calculate the frequency of alternating electric currents generated by the Earth.

Plain Language Summary - PLS: Currently, the Earth, like every cosmic body, is electric neutral. However, I prove that the Earth (all cosmic bodies) has electric charge and electric potential, meaning it is not electric neutral. For the first time I unified gravitational force with electric force. Only through this unification it results that the Earth is a generator of electricity. In some practical applications we have suggested the use of the electricity of the Earth, the Moon. The inner core rotates in the opposite direction to the outer core. The earth as a generator of electricity is a dynamo whose rotor is an alternator.

Keywords: Dynamic astronomy - Solar system - Earth - Physics - electric field - frequency of electricity.

1 INTRODUCTION

Generally speaking, the electric potential of Earth has typically been considered to be Zero. I shall subsequently be demonstrating how all cosmic bodies have an electric charge, as well as electric potential. There are no electrically neutral bodies that exist in the cosmos; all bodies are electrically charged. The theoretically proven results I shall be demonstrating in this investigation are all consistent with established findings.

According to the (nssdc.earthfact. 2019), the Earth's mass is $m = 5.9724 \cdot 10^{24} \text{ kg}$, its equatorial radius is $r_e = 6.378137 \cdot 10^6 \text{ m}$, its polar radius is $r_p = 6.356752 \cdot 10^6 \text{ m}$, its mean radius is $r = 6.371 \cdot 10^6 \text{ m}$, its volume is $V = 1.08321 \cdot 10^{21} \text{ m}^3$, its mean density is $\rho = 5514 \text{ kg m}^{-3}$, its equatorial rotation velocity is $v = 4.651 \cdot 10^2 \text{ m s}^{-1}$, its average surface temperature is $T = 288 \text{ K} (15^\circ \text{ C})$, and the average gravitational acceleration at the Earth's surface is $g = 9.807 \text{ m s}^{-2}$. According to (Robertson 2011; Jordan 1979) the inner structure of the Earth is made up of a core, a mantle and a crust. If we begin at the surface, the Earth's crust has a thickness falling within a range of $(3 - 6)10^4 \text{ m}$, which is solid. After this, we find a liquid mantle, which reaches down to a depth of

approximately $2.9 \cdot 10^6 m$ and, finally, the core, which reaches right into the centre. The core consists of a solid inner core and a liquid outer core. The solid inner core measurements are $r \approx 1.2 \cdot 10^6 m$, $m \approx 8 \cdot 10^{22} kg$, $\rho \approx 1.2 \cdot 10^4 kg m^{-3}$, $T \approx (5 - 6)10^3 K$. The liquid outer core measurements are $r \approx 3.47 \cdot 10^6 m$, $m \approx 1.7 \cdot 10^{24} kg$, $\rho \approx 10^4 kg m^{-3}$, $T \approx (4 - 5)10^3 K$. Between the liquid mantle and the liquid outer core, we find the Gutenberg discontinuity (described as “D”), which has a depth of $2 \cdot 10^5 m$.

2 THE MAGNETIC FIELD

Newton’s universal law of attraction is

$$\mathbf{F} = -G \frac{m_1 \cdot m_2}{r^2} \frac{\mathbf{r}}{r} N \text{ or } F = G \frac{m_1 \cdot m_2}{r^2} N \text{ with } \frac{\mathbf{r}}{r} = 1 \text{ in module} \quad (1)$$

where m_1 and m_2 are the masses of two bodies, r is the distance between them and $G = 6.67430(15) \cdot 10^{-11} m^3 kg^{-1} s^{-2}$ constant of universal attraction (CODATA 2019). The negative sign originates from the inverse orientations of the vectors \mathbf{F} and \mathbf{r} .

Coulomb’s law is

$$\mathbf{F} = \frac{1}{4\pi\epsilon_0} \frac{q_1 \cdot q_2}{r^2} \frac{\mathbf{r}}{r} N \text{ or } F = \frac{1}{4\pi\epsilon_0} \frac{q_1 \cdot q_2}{r^2} N \text{ with } \frac{\mathbf{r}}{r} = 1 \text{ in module} \quad (2)$$

where q_1 and q_2 are the electrical charge, r is the distance between each other and $\epsilon_0 = 8.8541878128(13) \cdot 10^{-12} F m^{-1}$ electrical permittivity of vacuum (CODATA 2019). Through the equivalence outcome between (1) with (2) result (3), with $m_1 = m_2 = m$ and $q_1 = q_2 = q$, which represents the combination of the gravitational and electric forces. The equivalence relation between the mass m of the material body and its electric charge q is

$$m = \pm(4\pi\epsilon_0 G)^{-1/2} \cdot q \text{ kg and } q = \pm(4\pi\epsilon_0 G)^{1/2} \cdot m \text{ C} \quad (3)$$

Magnetic induction \mathbf{B} at a point P (under the Biot-Savart law) is:

$$\mathbf{B} = \frac{\mu_0}{4\pi^2} \frac{q \cdot \mathbf{v}}{r^2} T \quad (4)$$

where $\mu_0 = 1.25663706212(19) \cdot 10^{-6} N A^{-2}$ is the vacuum magnetic permeability (CODATA 2019), \mathbf{v} = speed of electric charge q and r = distance from the centre of electric charge q to the point of observation P . By introducing (3) along with (4), we get

$$\mathbf{B} = \frac{\mu_0(4\pi\epsilon_0 G)^{1/2}}{4\pi^2} \frac{m \cdot \mathbf{v}}{r^2} T \quad (5)$$

According to the (nssdc.earthfact. 2019), the average approximation of magnetic induction \mathbf{B} , at the Earth’s surface, is $\mathbf{B} \approx 5.15 \cdot 10^{-5} T$. With (5), the mass that generates the magnetic induction \mathbf{B} is:

$$m = 1.64 \cdot 10^{24} kg$$

with $r = 6.378137 \cdot 10^6 m$ as the equatorial radius, and $v = 4.651 \cdot 10^2 m s^{-1}$ of equatorial rotation velocity. However, according to established data, $m = 1.64 \cdot 10^{24} kg$ represents the mass of the Earth’s core.

With (5), the core is like an alternator generating the Earth’s magnetic field. The rotor of

this alternator can be seen in Earth's solid inner core, behaving as a permanent magnet and an inductor. The stator of this alternator could therefore be seen as the liquid outer core, which is induced, just like an electrical inductor coil. As the solid inner core rotates, the magnetic induction \mathbf{B} is induced in this coil-type carrier, serving here as the Earth's liquid outer core. From this location it penetrates through the mantle and the crust, spreading through the entire planet. In this way, the entire core generates the electromagnetic field of the planet. This is the process for all natural cosmic bodies.

According to (Livermore et al. 2013), the inner core rotates eastward, while the outer core rotates westward, thus stirring the mantle and crust into motion. In 1692, Edmund Halley demonstrated the westward-spinning motion of the Earth's geomagnetic field. In recent decades, seismometers have identified an eastwards rotation of the solid inner core, relative to the westward-rotating surface of the planet. Earth's solid inner core is surrounded by the liquid of its outer core. This is composed of an iron alloy, while its rotation generates the Earth's magnetic field. Therefore, the inner core of the planet rotates eastwards around its axis, moving towards the right, or clockwise, if we place ourselves at the North Pole. The outer core, with the surface of the planet, rotates westwards around the axis, moving towards the left, or counter clockwise, if we place ourselves at the North Pole. This situation would thus be reversed if we placed ourselves at the South Pole.

3 THE ELECTRIC FIELD

The intensity of the gravitational field \mathbf{E} created by a body of mass m is

$$\mathbf{E} = -G \frac{m}{r^2} \frac{\mathbf{r}}{r} \text{ N kg}^{-1} \text{ or } E = G \frac{m}{r^2} \text{ N kg}^{-1} \text{ with } \frac{\mathbf{r}}{r} = 1 \text{ in module} \quad (6)$$

where r =body radius. By introducing (3) into (6) we obtain

$$\mathbf{E} = \left(\frac{G}{4\pi\epsilon_0} \right)^{1/2} \frac{q}{r^2} \text{ V m}^{-1} \quad (7)$$

with q =the electric charge of the body of mass m . Just as with alternator, this core generates a magnetic and electric field, or an electromagnetic field. The mass of the core, which generates \mathbf{B} with (5) is $m = 1.64 \cdot 10^{24} \text{ kg}$. Therefore, $m = 1.64 \cdot 10^{24} \text{ kg}$ also generates the electric field. Earth's mantle and crust are thus like the housing of the alternator. With (3) the electric charge q of the core mass is

$$q = \pm 1.4 \cdot 10^{14} \text{ C}$$

The intensity of the electric field at the Earth's surface with (7) is

$$E = \pm 2.7 \text{ V m}^{-1}$$

with r =the average radius of the Earth. With (6) we have the same result in N kg^{-1} . Therefore \mathbf{E} is generated by the core, behaving like its alternator. The gravitational potential at distance r is

$$V = -G \frac{m}{r} \text{ J kg}^{-1} \quad (8)$$

Because \mathbf{E} and \mathbf{B} are generated by the core of the cosmic body, not because of the total mass of the cosmic body, m = mass of the cosmic body core. In (8) we put (3) and results

$$V = \pm \left(\frac{G}{4\pi\epsilon_0} \right)^{-1/2} \frac{q}{r} \text{ V} \quad (9)$$

with q =electric charge of the mass m . The electric (electrostatic) potential at the Earth's surface with (9) is:

$$V = \pm 1.7 \cdot 10^7 \text{ V}$$

with r = average radius and $q = 1.4 \cdot 10^{14} \text{ C}$ electric charge of the core's mass. With (8) we have the same result in $J \text{ kg}^{-1}$. This is the calculation for the electrostatic (gravitational) potential of all natural cosmic bodies. That is to say, there are no electrically neutral bodies that exist in the cosmos, all bodies are electrically charged, as all are points of electrical charge. Generally speaking, the electric potential of Earth has typically been considered to be Zero. In reality, all cosmic bodies have an electric charge, as well as electric potential.

According to the (nssdc.earthfact. 2019),equatorial radius is $r_e = 6.378137 \cdot 10^6 \text{ m}$ and its polar radius is $r_p = 6.356752 \cdot 10^6 \text{ m}$. With (9) the electric potential is the equator

$$V = \pm 1.70046 \cdot 10^7 \text{ V}$$

with r = equatorial radius. With (9) at the poles we have

$$V = \pm 1.70618 \cdot 10^7 \text{ V}$$

with r = polar radius. The equator-to-pole difference in electric potential is

$$V = \pm 5.72 \cdot 10^4 \text{ V}$$

This would mean it is around 57200 V. We can capture electricity in the South Pole, through the soil or subsoil of Antarctica, using technology to pass it through a type of power plant. From this, we then distribute it through the Earth's electrical network. Being an alternative form of electric energy, the electric network should be at the equator on a mountain as high as possible, so that the potential difference between the network (poles) and the mass Earth (equator) is as large as possible. Or at the North Pole on the bottom of the Arctic Ocean, depth over 4000 meters. Alternating and ground power terminals can be made at shorter distances, but then we have a smaller potential difference in the network. The terminals should only be made on the meridians (north-south), where the potential difference per meter is $V = 5.73 \cdot 10^{-3} \text{ V}$

The mantle is considered to be an electrical insulator. The magma of volcanoes is also the liquid mantle at the Earth's surface. We can introduce a metal cable into a volcano to capture the electric potential of this magma. This cable needs to be inserted as deep as possible into the magma, in order to withstand the magma temperatures of above 1000° C , and to be isolated from the Earth's crust, where the mass of the electrical network is found. By placing a meter between the magma cable and the ground cable, within the solid crust of the Earth, we can determine whether there is a difference in the electric potential. If there is, then using the correct technology, we can then capture the electricity produced by volcanoes and distribute this through the Earth's electrical network.

We can generate electricity from the Moon. To do this, we need to connect the surface of the Moon to the Earth receiver station, such as Tesla's Wardencliff Tower, using an electromagnetic cable. From here the electricity is distributed throughout the network. According to the (nssdc.moonfact. 2020), the Moon has a mass core $m \approx 10^{21} \text{ kg}$ and an average radius of $1.7374 \cdot 10^6 \text{ m}$. With (3) the electric charge of the mass core is

$$q \approx \pm 8.6 \cdot 10^{10} \text{ C}$$

With (9) the electric potential on the surface of the Moon is

$$V = \pm 3.8 \cdot 10^4 \text{ V}$$

The Earth-to-Moon difference in electric potential is:

$$V \approx \pm 1.69 \cdot 10^7 \text{ V}$$

This represents a difference of electric potential between the Earth and the Moon, so we can capture the electrical energy of the Moon, and so use it within the electrical network on the

Earth.

4 THE FREQUENCY OF ELECTRICAL ENERGY

At the core to mantle boundary, $r = 3.47 \cdot 10^6 \text{ m}$, the magnetic induction according to (Livermore et al. 2013) is $\mathbf{B} = 2.6 \cdot 10^{-4} \text{ T}$, to (Gillet et al. 2010) it is $\mathbf{B} = (3 - 7)10^{-4} \text{ T}$ and to (Pichon et al. 2016) it is $\mathbf{B} = 4 \cdot 10^{-4} \text{ T}$. We took the approximate average of $\mathbf{B} = 4.6 \cdot 10^{-4} \text{ T}$. With (5), we obtain

$$\mathbf{v} = 1.24 \cdot 10^3 \text{ m s}^{-1}$$

where v =equatorial rotational velocity of the core at the core to mantle boundary and $m = 1.64 \cdot 10^{24} \text{ kg}$ being the mass of the core. At the outer core to inner core boundary, $r = 1.2 \cdot 10^6 \text{ m}$, with (5) we obtain

$$\mathbf{B} = 3.8 \cdot 10^{-3} \text{ T}$$

where \mathbf{B} =magnetic induction of the outer core at the boundary with the inner core, $m = 1.64 \cdot 10^{24} \text{ kg}$ and $v = 1.24 \cdot 10^3 \text{ m s}^{-1}$. While in (Gillet et al. 2010) this is $\mathbf{B} = (2 - 4)10^{-3} \text{ T}$, to (Dumberry et al. 2002) this is $\mathbf{B} = (3 - 4)10^{-3} \text{ T}$ and in (Pichon et al. 2016) this is $\mathbf{B} = 2.8 \cdot 10^{-3} \text{ T}$. Therefore, (5) is true.

According to (Cox et al. 2013; Livermore et al. 2013) the inner core is deemed to have a strong electromagnetic, gravitational coupling with the outer core. Since the inner core rotates in the opposite direction to the outer core, at the outer to inner core boundary, $r = 1.2 \cdot 10^6 \text{ m}$, Newton's Second and Third Laws of Mechanics apply, in accordance with general relativity. We get

$$\mathbf{v} = 3.3 \cdot 10^3 \text{ m s}^{-1}$$

where v =equatorial rotation velocity of the inner core at the boundary of the outer core $r = 1.2 \cdot 10^6 \text{ m}$, with $m = 1.64 \cdot 10^{24} \text{ kg}$ core and $M = 8 \cdot 10^{22} \text{ kg}$ inner core. With (5) we obtain

$$\mathbf{B} = 10^{-2} \text{ T}$$

where \mathbf{B} =magnetic induction of the inner core at $r = 1.2 \cdot 10^6 \text{ m}$ and $m = 1.64 \cdot 10^{24} \text{ kg}$ core mass. In (Buffet et al. 2002) this is $\mathbf{B} = 7.17 \cdot 10^{-3} \text{ T}$ with the maximum being $\mathbf{B} = (1 - 2)10^{-2} \text{ T}$. The magnetic and electric field, or the electromagnetic field, is generated by the core. The mantle and the core are like the housing of Earth's electricity generator. This is the case in all cosmic and atomic bodies.

The frequency of the alternating electric currents produced by the alternator is

$$f = n \frac{p}{120} \text{ Hz} \quad (10)$$

where n =revolutions (rotations) of the rotor in revolutions/minute and p =number of magnetic poles. The numerical factor 120 is 60 seconds/minute with two poles in a magnet. According to (Cox et al. 2013; Livermore et al. 2013) the inner core rotates faster than the outer core, and in opposing directions to each other. Therefore, the speeds accumulate and result in

$$\mathbf{v} = (1.24 + 3.3)10^3 = 4.54 \cdot 10^3 \text{ m s}^{-1}$$

With this speed at $r = 1.2 \cdot 10^6 \text{ m}$ we get

$$n = 3.6 \cdot 10^{-2} \text{ revolutions/minute}$$

The inner core consists of at least one permanent magnet with two poles, North and South, in other words $p = 2$. By bringing in (10) we obtain the frequency

$$f = 6 \cdot 10^{-4} \text{ Hz}$$

The minimum frequency of alternating electric currents produced by the Earth is approximately $f \approx (10^{-3} - 10^{-4}) \text{ Hz}$. Around the entire surface of the Earth there exists an ambient noise, with a minimum value of $(10^{-3} - 10^{-4}) \text{ Hz}$. If, on observation, a higher frequency were found, then the inner core would consist of several permanent magnets. Therefore, we can find the number of coils, or equivalent coil-type carriers, which form the outer core. The Earth is a generator of electricity, as are all cosmic and atomic bodies. In other words, it is like an alternator in a dynamo. I state this because Earth's solid crust possesses natural magnetic properties, just as the magnetic stator of a dynamo does.

5 CONCLUSION

The Earth is like a dynamo, whose rotor behaves like its alternator. The difference here is that on Earth the crust rotates, while the stator of a dynamo is fixed. However, the equatorial rotation velocity of the Earth's crust, $v = 465.1 \text{ m s}^{-1}$, is less than that of its outer core $v = 1240 \text{ m s}^{-1}$. Though both of these have the same meaning, this analogy can still be made.

The alternator consists of two rotors, which rotate in opposing directions to each other. The inner rotor is the inner core, which rotates towards the right, being eastwards, or clockwise, if we are at the North Pole. The outer rotor is the outer core which rotates towards the left, being westwards, or counter clockwise, if we are the North Pole. This situation would thus be reversed if we placed ourselves at the South Pole. The outer core is induced and the crust and the inner core behave as though they are the inductors.

Alternating electric currents are produced by the outer core through induction. Alternating electric currents are generated by the crust, which behaves as though an inductor. Alternating electric currents are produced from the inner core, which behaves as though inductor. Alternating electric currents flow from the outer core, which is induced, and on through the liquid mantle, throughout the Earth. This reaches the exterior of Earth's solid crust, on which we live our lives. It is possible that Earth's mantle is only partially insulated. The frequency of its alternating electric currents is of, at least, $f \approx (10^{-3} - 10^{-4}) \text{ Hz}$. Ambient noise is present around the entire surface of the Earth, which can be detected through the use of specialised technology. The electric potential at the Earth's surface is $V = \pm 1.7 \cdot 10^7 \text{ V}$.

The electric and magnetic field, the electromagnetic field, is generated by the core of the cosmic body, not by the entire mass of the cosmic body. The mass difference between the total mass of the cosmic body and the mass of the core of the cosmic body, is the dark matter which generates the dark energy.

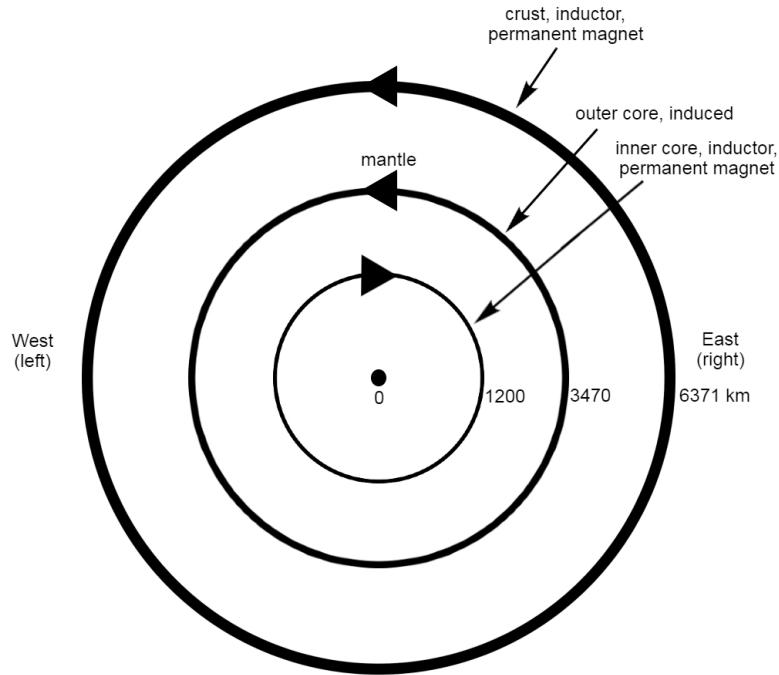


Figure 1: Earth as an electric generator

Data Availability Statement

The data on which this article is based is available in Fundamental Physical Constants [2019], nssdc.nasa.gov/earthfact [2019], sunfact [2018], moonfact [2020], Livermore et al. [2013], Gillet et al. [2016], Dumberry et al. [2002], Cox et al. [2013], Buffet et al. [2002].
With special thanks to Livermore et al. [2013].

BIBLIOGRAPHY

Buffet B.A., Mathews P.A., Herring T.A. (2002), Modelling of nutation and precession: Effects of nutation and precession: Effects of electromagnetic coupling, *Journal of Geophysical Research*, 107: 5.1 - 5.15.

Cox G.A., Livermore P.W., Mound J.E., Forward models of torsional waves: Dispersion and Geometric Effects, *Geophysical Journal International*, 7 nov. 2013.

Livermore Philip W., Hollerbach Rainier, Jackson Andrew, Electromagnetically driven westward drift and inner-core superrotation in Earth's core, *Institute of Geophysics and Planetary Physics*, Los Angeles, CA, 26 aug. 2013; Proceedings of the National Academy of Sciences Oct. 2013, 110(40) 15914-15918; DOI: 10.1073 / pnas.1307825110.

Mathieu Dumberry, Jeremy Bloxham, Inner core tilt and polar motion, *Geophysical Journal International*, volume **151**, issue 2, Nov. 2002, pages 377-392, <https://doi.org/10.1046/j.1365-246X.2002.01756.x>

Nicolas Gillet, Dominique Jault, Elisabeth Canet & Alexandre Fournier, Fast torsional waves and strong magnetic field within the Earth's core, *Nature*, Vol **465**/6 May 2010/doi: 10.1038/nature09010.

Pichon Guillaume, Aubert Julien, Fournier Alexandre, Coupled dynamics of Earth's geomagnetic westward drift and inner core super-rotation, *Earth and Planetary Science Letters*, **437** (2016) 114 – 126.

[http://pubs.usgs.gov/gip/interior/The interior of the Earth](http://pubs.usgs.gov/gip/interior/The%20interior%20of%20the%20Earth.pdf), Eugene C. Robertson, 14 jan. 2011.

Jordan T. H. (1979): "Structural Geology of the Earth's Interior"(PDF). Proceedings of the National Academy of Sciences. **76**(9) 4142-4200. Bibcode: 1979 PNAS...76.4192 J.doi:10.1073/pnas.76.9.4192.PMC 411539.PMID 16592703.

<https://nssdc.gsfc.nasa.gov/planetaryfactsheet/earthfact.html>, 22 april 2019.

<http://nssdc.gsfc.nasa.gov/planetaryfactsheet/sunfact.html>, 23 febr. 2018.

<http://nssdc.gsfc.nasa.gov/planetaryfactsheet/moonfact.html>, 13 jan. 2020.

<https://physics.rist.gov/cuu/Constants/CODATA> internationally recommended 2018 values of the Fundamental Physical Constants, May 2019.