

# A System to convert Gravitational Energy directly into Electrical Energy

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We show that it is possible to produce *strong gravitational accelerations on the free electrons of a conductor* in order to obtain electrical current. This allows the conversion of gravitational energy directly into electrical energy. Here, we propose a system that can produce several tens of kilowatts of electrical energy converted from the gravitational energy.

**Key words:** Modified theories of gravity, Electric fields effects on material flows, Electron tubes, Electrical instruments.  
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## 1. Introduction

In a previous paper [1], we have proposed a system to convert gravitational energy into rotational kinetic energy (*Gravitational Motor*), which can be converted into electrical energy by means of a conventional electrical generator. Now, we propose a novel system to convert gravitational energy *directly* into electrical energy.

It is known that, in some materials, called *conductors*, the free electrons are so loosely held by the atom and so close to the neighboring atoms that they tend to drift randomly from one atom to its neighboring atoms. This means that the electrons move in all directions by the same amount. However, if some outside force acts upon the free electrons their movement becomes not random, and they move from atom to atom at the same direction of the applied force. This flow of electrons (their electric charge) through the conductor produces the *electrical current*, which is defined as a flow of electric charge through a medium [2]. This charge is typically carried by moving electrons in a conductor, but it can also be carried by ions in an electrolyte, or by both ions and electrons in a plasma [3].

Thus, the electrical current arises in a conductor when an outside force acts upon the free electrons. This force is called, in a generic way, of *electromotive force* (EMF). Usually, it is of *electrical* nature ( $F = eE$ ).

Here, it is shown that the electrical flow can also be achieved by means of *gravitational* forces ( $F = m_e g$ ). The *Gravitational Shielding Effect* (BR Patent Number: PI0805046-5, July 31, 2008 [4]), shows that a battery of Gravitational Shieldings can strongly intensify the gravitational acceleration in any direction and, in this way, it is possible to *produce strong gravitational accelerations on the free electrons of a conductor* in order to obtain electrical current.

## 2. Theory

From the quantization of gravity it follows that the *gravitational mass*  $m_g$  and the *inertial mass*  $m_i$  are correlated by means of the following factor [1]:

$$\chi = \frac{m_g}{m_{i0}} = \left\{ 1 - 2 \left[ \sqrt{1 + \left( \frac{\Delta p}{m_{i0} c} \right)^2} - 1 \right] \right\} \quad (1)$$

where  $m_{i0}$  is the *rest* inertial mass of the particle and  $\Delta p$  is the variation in the particle's *kinetic momentum*;  $c$  is the speed of light.

When  $\Delta p$  is produced by the absorption of a photon with wavelength  $\lambda$ , it is expressed by  $\Delta p = h/\lambda$ . In this case, Eq. (1) becomes

$$\frac{m_g}{m_{i0}} = \left\{ 1 - 2 \left[ \sqrt{1 + \left( \frac{h/m_{i0}c}{\lambda} \right)^2} - 1 \right] \right\}$$

$$= \left\{ 1 - 2 \left[ \sqrt{1 + \left( \frac{\lambda_0}{\lambda} \right)^2} - 1 \right] \right\} \quad (2)$$

where  $\lambda_0 = h/m_{i0}c$  is the *De Broglie wavelength* for the particle with *rest* inertial mass  $m_{i0}$ .

It has been shown that there is an additional effect - *Gravitational Shielding* effect - produced by a substance whose gravitational mass was reduced or made negative [5]. The effect extends beyond substance (gravitational shielding), up to a certain distance from it (along the central axis of gravitational shielding). This effect shows that in this region the gravity acceleration,  $g_1$ , is reduced at the same proportion, i.e.,  $g_1 = \chi_1 g$  where  $\chi_1 = m_g/m_{i0}$  and  $g$  is the gravity acceleration *before* the gravitational shielding). Consequently, *after a second gravitational shielding*, the gravity will be given by  $g_2 = \chi_2 g_1 = \chi_1 \chi_2 g$ , where  $\chi_2$  is the value of the ratio  $m_g/m_{i0}$  for the *second* gravitational shielding. In a generalized way, we can write that after the  $n$ th gravitational shielding the gravity,  $g_n$ , will be given by

$$g_n = \chi_1 \chi_2 \chi_3 \dots \chi_n g \quad (3)$$

This possibility shows that, by means of a battery of gravitational shieldings, we can make particles acquire enormous accelerations. In practice, this can lead to the conception of powerful particles accelerators, kinetic weapons or weapons of shockwaves.

From Electrodynamics we know that when an electromagnetic wave with frequency  $f$  and velocity  $c$  incides on a material with relative permittivity  $\epsilon_r$ , relative magnetic permeability  $\mu_r$  and electrical conductivity  $\sigma$ , its *velocity is reduced* to  $v = c/n_r$ , where  $n_r$  is the index of refraction of the material, given by [6]

$$n_r = \frac{c}{v} = \sqrt{\frac{\epsilon_r \mu_r}{2} \left( \sqrt{1 + (\sigma/\omega\epsilon)^2} + 1 \right)} \quad (4)$$

If  $\sigma \gg \omega\epsilon$ ,  $\omega = 2\pi f$ , Eq. (4) reduces to

$$n_r = \sqrt{\frac{\mu_r \sigma}{4\pi\epsilon_0 f}} \quad (5)$$

Thus, the wavelength of the incident radiation (See Fig. 1) becomes

$$\lambda_{\text{mod}} = \frac{v}{f} = \frac{c/f}{n_r} = \frac{\lambda}{n_r} = \sqrt{\frac{4\pi}{\mu f \sigma}} \quad (6)$$

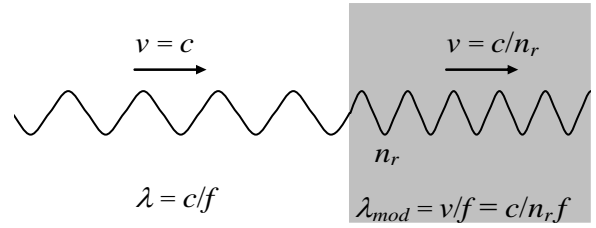


Fig. 1 – *Modified Electromagnetic Wave*. The wavelength of the electromagnetic wave can be strongly reduced, but its frequency remains the same.

If a lamina with thickness equal to  $\xi$  contains  $n$  atoms/ $m^3$ , then the number of atoms per area unit is  $n\xi$ . Thus, if the electromagnetic radiation with frequency  $f$  incides on an area  $S$  of the lamina it reaches  $nS\xi$  atoms. If it incides on the *total area of the lamina*,  $S_f$ , then the total number of atoms reached by the radiation is  $N = nS_f \xi$ . The number of atoms per unit of volume,  $n$ , is given by

$$n = \frac{N_0 \rho}{A} \quad (7)$$

where  $N_0 = 6.02 \times 10^{26}$  atoms/kmole is the Avogadro's number;  $\rho$  is the matter density of the lamina (in  $kg/m^3$ ) and  $A$  is the molar mass( $kg/kmole$ ).

When an electromagnetic wave incides on the lamina, it strikes  $N_f$  front atoms, where  $N_f \cong (nS_f)\phi_m$ ,  $\phi_m$  is the "diameter" of the atom. Thus, the electromagnetic wave incides effectively on an area  $S = N_f S_m$ , where  $S_m = \frac{1}{4} \pi \phi_m^2$  is the cross section area of one atom.

After these collisions, it carries out  $n_{collisions}$  with the other atoms (See Fig.2).

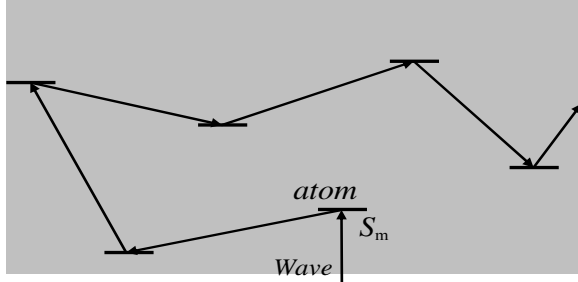


Fig. 2 – Collisions inside the lamina.

Thus, the total number of collisions in the volume  $S\xi$  is

$$\begin{aligned} N_{collisions} &\cong N_f + n_{collisions} \cong n_l S \phi_m + (n_l S \xi - n_m S \phi_m) = \\ &= n_m S \xi \end{aligned} \quad (8)$$

The power density,  $D$ , of the radiation on the lamina can be expressed by

$$D = \frac{P}{S} = \frac{P}{N_f S_m} \quad (9)$$

We can express the *total mean number of collisions in each atom*,  $n_1$ , by means of the following equation

$$n_1 = \frac{n_{total \ photons} N_{collisions}}{N} \quad (10)$$

Since in each collision a *momentum*  $h/\lambda$  is transferred to the atom, then the *total momentum* transferred to the lamina will be  $\Delta p = (n_1 N)h/\lambda$ . Therefore, in accordance with Eq. (1), we can write that

$$\begin{aligned} \frac{m_g(t)}{m_{i0}(t)} &= \left\{ 1 - 2 \left[ \sqrt{1 + \left[ (n_1 N) \frac{\lambda_0}{\lambda} \right]^2} - 1 \right] \right\} = \\ &= \left\{ 1 - 2 \left[ \sqrt{1 + \left[ n_{total \ photons} N_{collisions} \frac{\lambda_0}{\lambda} \right]^2} - 1 \right] \right\} \end{aligned} \quad (11)$$

Since Eq. (8) gives  $N_{collisions} = n_l S \xi$ , we get

$$n_{total \ photons} N_{collisions} = \left( \frac{P}{hf^2} \right) (n_l S \xi) \quad (12)$$

Substitution of Eq. (12) into Eq. (11) yields

$$\frac{m_g(t)}{m_{i0}(t)} = \left\{ 1 - 2 \left[ \sqrt{1 + \left[ \left( \frac{P}{hf^2} \right) (n_l S \xi) \frac{\lambda_0}{\lambda} \right]^2} - 1 \right] \right\} \quad (13)$$

Substitution of  $P$  given by Eq. (9) into Eq. (13) gives

$$\frac{m_g(t)}{m_{i0}(t)} = \left\{ 1 - 2 \left[ \sqrt{1 + \left[ \left( \frac{N_f S_m D}{f^2} \right) \left( \frac{n_l S \xi}{m_{i0}(t) c} \right) \frac{1}{\lambda} \right]^2} - 1 \right] \right\} \quad (14)$$

Substitution of  $N_f \cong (n_l S_f) \phi_m$  and  $S = N_f S_m$  into Eq. (14) results

$$\frac{m_g(t)}{m_{i0}(t)} = \left\{ 1 - 2 \left[ \sqrt{1 + \left[ \left( \frac{n_l^3 S_f^2 S_m^2 \phi_m^2 D}{m_{i0}(t) c f^2} \right) \frac{1}{\lambda} \right]^2} - 1 \right] \right\} \quad (15)$$

where  $m_{i0}(t) = \rho_{(t)} V_{(t)}$ .

Now, considering that the lamina is inside an ELF electromagnetic field with  $E$  and  $B$ , then we can write that [7]

$$D = \frac{n_r(t) E^2}{2\mu_0 c} \quad (16)$$

Substitution of Eq. (16) into Eq. (15) gives

$$\frac{m_g(t)}{m_{i0}(t)} = \left\{ 1 - 2 \left[ \sqrt{1 + \left[ \left( \frac{n_r(t) n_l^3 S_f^2 S_m^2 \phi_m^2 E^2}{2\mu_0 m_{i0}(t) c^2 f^2} \right) \frac{1}{\lambda} \right]^2} - 1 \right] \right\} \quad (17)$$

In the case in which the area  $S_f$  is just the *area of the cross-section of the lamina* ( $S_\alpha$ ), we obtain from Eq. (17), considering that  $m_{i0}(t) = \rho_{(t)} S_\alpha \xi$ , the following expression

$$\frac{m_{g(l)}}{m_{i0(l)}} = \left\{ 1 - 2 \left[ \sqrt{1 + \left[ \left( \frac{n_{r(l)} n_l^3 S_\alpha S_m^2 \phi_m^2 E^2}{2\mu_0 \rho_{(l)} c^2 f^2} \right) \frac{1}{\lambda} \right]^2} - 1 \right] \right\} \quad (18)$$

If the electrical conductivity of the lamina,  $\sigma_{(l)}$ , is such that  $\sigma_{(l)} \gg \omega \epsilon$ , then the value of  $\lambda$  is given by Eq. (6), i.e.,

$$\lambda = \lambda_{\text{mod}} = \sqrt{\frac{4\pi}{\mu f \sigma}} \quad (19)$$

Substitution of Eq. (19) into Eq. (18) gives

$$\frac{m_{g(l)}}{m_{i0(l)}} = \left\{ 1 - 2 \left[ \sqrt{1 + \frac{n_{r(l)}^2 n_l^6 S_\alpha^2 S_m^4 \phi_m^4 \sigma_{(l)} E^4}{16\pi \mu_0 \rho_{(l)}^2 c^4 f^3}} - 1 \right] \right\} \quad (20)$$

Note that  $E = E_m \sin \omega t$ . The average value for  $E^2$  is equal to  $\frac{1}{2} E_m^2$  because  $E$  varies sinusoidally ( $E_m$  is the maximum value for  $E$ ). On the other hand,  $E_{\text{rms}} = E_m / \sqrt{2}$ . Consequently we can change  $E^4$  by  $E_{\text{rms}}^4$ , and the equation above can be rewritten as follows

$$\chi = \frac{m_{g(l)}}{m_{i0(l)}} = \left\{ 1 - 2 \left[ \sqrt{1 + \frac{n_{r(l)}^2 n_l^6 S_\alpha^2 S_m^4 \phi_m^4 \sigma_{(l)} E_{\text{rms}}^4}{16\pi \mu_0 \rho_{(l)}^2 c^4 f^3}} - 1 \right] \right\} \quad (21)$$

Now consider the system shown in Fig.4. It was designed to convert *Gravitational Energy* directly into *Electrical Energy*. Thus, we can say that it is a *Gravitational EMF Source*.

Inside the system there is a *dielectric tube* ( $\epsilon_r \cong 1$ ) with the following characteristics:  $\alpha = 8\text{mm}$  (diameter),  $S_\alpha = \pi \alpha^2 / 4 = 5.03 \times 10^{-5} \text{m}^2$ . Inside the tube there is a *Lead sphere* with 4mm radius and mass  $M_{gs} = 3.04 \times 10^{-3} \text{kg}$ . The tube is filled with *air* at ambient temperature and 1atm. Thus, inside the tube, the air density is

$$\rho_{\text{air}} = 1.2 \text{ kg} \cdot \text{m}^{-3} \quad (22)$$

The number of atoms of air (Nitrogen) per unit of volume,  $n_{\text{air}}$ , according to Eq.(7), is given by

$$n_{\text{air}} = \frac{N_0 \rho_{\text{air}}}{A_N} = 5.16 \times 10^{25} \text{ atoms} / \text{m}^3 \quad (23)$$

The *parallel metallic plates* (p), shown in Fig.4 are subjected to different drop voltages. The two sets of plates (D), placed on the extremes of the tube, are subjected to  $V_{(D)\text{rms}} = 3.847 \text{ kV}$  at  $f = 60\text{Hz}$ , while the central set of plates (A) is subjected to  $V_{(A)\text{rms}} = 7.868 \text{ kV}$  at  $f = 60\text{Hz}$ . Since  $d = 14\text{mm}$ , then the intensity of the electric field, which passes through the 36 *cylindrical air laminas* (each one with 5mm thickness) of the two sets (D), is

$$E_{(D)\text{rms}} = V_{(D)\text{rms}} / d = 2.748 \times 10^5 \text{ V} / \text{m}$$

and the intensity of the electric field, which passes through the 19 *cylindrical air laminas* of the central set (A), is given by

$$E_{(A)\text{rms}} = V_{(A)\text{rms}} / d = 5.62 \times 10^5 \text{ V} / \text{m}$$

Note that the *metallic rings* (5mm thickness) are positioned in such way to block the electric field out of the cylindrical air laminas. The objective is to turn each one of these laminas into a *Gravity Control Cells* (GCC) [5]. Thus, the system shown in Fig. 3 has 3 sets of GCC. Two with 18 GCC each, and one with 19 GCC. The two sets with 18 GCC each are positioned at the extremes of the tube (D). They work as *gravitational decelerator* while the other set with 19 GCC (A) works as a *gravitational accelerator*, intensifying the gravity acceleration produced by the mass  $M_{gs}$  of the Lead sphere. According to Eq. (3), this gravity, after the 19<sup>th</sup> GCC becomes  $g_{19} = \chi^{19} GM_{gs} / r_0^2$ , where  $\chi = m_{g(l)} / m_{i(l)}$

given by Eq. (21) and  $r_0 = 9mm$  is the distance between the center of the Lead sphere and the surface of the first GCC of the set (A).

The objective of the sets (D), with 18 GCC each, is to reduce strongly the value of the external gravity along the axis of the tube. In this case, the value of the external gravity,  $g_{ext}$ , is reduced by the factor  $\chi_d^{18} g_{ext}$ , where  $\chi_d = 10^{-2}$ . For example, if the base BS of the system is positioned on the Earth surface, then  $g_{ext} = 9.81m/s^2$  is reduced to  $\chi_d^{18} g_{ext}$  and, after the set A, it is increased by  $\chi^{19}$ . Since the system is designed for  $\chi = -6.513$ , then the gravity acceleration on the sphere becomes  $\chi^{19} \chi_d^{18} g_{ext} = 2.8 \times 10^{20} m/s^2$ , this value is much smaller than  $g_{sphere} = GM_{gs}/r_s^2 = 1.27 \times 10^{-8} m/s^2$ .

Note that there is a *uniform magnetic field*,  $B$ , through the *Copper rod*. The electrical conductivity of air, *inside the dielectric tube*, is equal to the electrical conductivity of Earth's atmosphere near the land, whose average value is  $\sigma_{air} \cong 1 \times 10^{-14} S/m$  [8]. This value is of fundamental importance in order to obtain the convenient values of the electrical current  $i$  and the value of  $\chi$  and  $\chi_d$ , which are given by Eq. (21), i.e.,

$$\chi = \left\{ 1 - 2 \left[ \sqrt{1 + \frac{n_{r(air)}^2 n_{air}^6 S_\alpha^2 S_m^4 \phi_m^4 \sigma_{air} E_{(A)rms}^4}{16\pi\mu_0 \rho_{air}^2 c^4 f^3}} - 1 \right] \right\} = \left\{ 1 - 2 \left[ \sqrt{1 + 2.165 \times 10^{-22} E_{(A)rms}^4} - 1 \right] \right\} \quad (24)$$

$$\chi_d = \left\{ 1 - 2 \left[ \sqrt{1 + \frac{n_{r(air)}^2 n_{air}^6 S_\alpha^2 S_m^4 \phi_m^4 \sigma_{air} E_{(D)rms}^4}{16\pi\mu_0 \rho_{air}^2 c^4 f^3}} - 1 \right] \right\} = \left\{ 1 - 2 \left[ \sqrt{1 + 2.165 \times 10^{-22} E_{(D)rms}^4} - 1 \right] \right\} \quad (25)$$

where  $n_{r(air)} = \sqrt{\epsilon_r \mu_r} \cong 1$ , since  $(\sigma \ll \omega\epsilon)$ ;  $n_{air} = 5.16 \times 10^{25} atoms/m^3$ ,  $\phi_m = 1.55 \times 10^{-10} m$ ,

$$S_m = \pi \phi_m^2 / 4 = 1.88 \times 10^{-20} m^2 \quad \text{and} \quad f = 60Hz.$$

Since  $E_{(A)rms} = 5.62 \times 10^5 V/m$  and  $E_{(D)rms} = 2.748 \times 10^5 V/m$ , we get

$$\chi = -6.513 \quad (26)$$

and

$$\chi_d \cong 10^{-2} \quad (27)$$

The *gravitational forces* due to the gravitational mass of the sphere ( $M_{gs}$ ) acting on *electrons* ( $F_e$ ), *protons* ( $F_p$ ) and *neutrons* ( $F_n$ ) of the Copper rod, are respectively expressed by the following relations

$$F_e = m_{ge} a_e = \chi_{Be} m_e \left( \chi^7 G \frac{M_{gs}}{r_0^2} \right) \quad (28)$$

$$F_p = m_{gp} a_p = \chi_{Bp} m_p \left( \chi^7 G \frac{M_{gs}}{r_0^2} \right) \quad (29)$$

$$F_n = m_{gn} a_n = \chi_{Bn} m_n \left( \chi^7 G \frac{M_{gs}}{r_0^2} \right) \quad (30)$$

*In order to make null the resultant of these forces in the Copper (and also in the sphere) we must have  $F_e = F_p + F_n$ , i.e.,*

$$m_e \chi_{Be} = m_p \chi_{Bp} + m_n \chi_{Bn} \quad (31)$$

It is important to note that *the set with 19 GCC (A) cannot be turned on before the magnetic field B is on*. Because the gravitational accelerations on the *Copper rod* and *Lead sphere* will be enormous ( $\chi^{19} GM_{gs}/r_0^2 \cong 7.25 \times 10 m/s^2$ ), and will explode the device.

The force  $F_e$  is the electromotive force (EMF), which produces the electrical current. Here, this force has *gravitational nature*. The corresponding force of *electrical nature* is  $F_e = eE$ . Thus, we can write that

$$m_{ge}a_e = eE \quad (32)$$

The electrons inside the *Copper* rod (See Fig. 4) are subjected to the gravity acceleration produced by the sphere, and increased by the 19 GCC in the region (A). The result is

$$a_e = \chi^{19} g_s = \chi^{19} G \frac{M_{gs}}{r_0^2} \quad (33)$$

Comparing Eq. (32) with Eq.(33), we obtain

$$E = \left( \frac{m_{ge}}{e} \right) \chi^{19} G \frac{M_{gs}}{r_0^2} \quad (34)$$

The electron mobility,  $\mu_e$ , considering various scattering mechanisms can be obtained by solving the Boltzmann equation in the relaxation time approximation. The result is [9]

$$\mu_e = \frac{e\langle\tau\rangle}{m_{ge}} \quad (35)$$

where  $\langle\tau\rangle$  is the average relaxation time over the electron energies and  $m_{ge}$  is the gravitational mass of electron, which is the effective mass of electron.

Since  $\langle\tau\rangle$  can be expressed by  $\langle\tau\rangle = m_{ge}\sigma/ne^2$  [10], then Eq. (35) can be written as follows

$$\mu_e = \frac{\sigma}{ne} \quad (36)$$

Thus, the *drift velocity* will be expressed by

$$v_d = \mu_e E = \frac{\sigma}{ne} \left( \frac{m_{ge}}{e} \right) \chi^{19} G \frac{M_{gs}}{r_0^2} \quad (37)$$

and the *electrical current density* expressed by

$$j_e = \rho_{qe} v_d = \sigma_{copper} \left( \frac{m_{ge}}{e} \right) \chi^{19} G \frac{M_{gs}}{r_0^2} \quad (38)$$

where  $\rho_{qe} = ne$ , and  $m_{ge} = \chi_{Be} m_e$  due to the electrons are inside the magnetic field  $B$ . Therefore, Eq. (38) reduces to

$$j_e = \sigma_{copper} \left( \frac{m_e}{e} \right) \chi_{Be} \chi^{19} G \frac{M_{gs}}{r_0^2} \quad (39)$$

In order to calculate the expressions of  $\chi_{Be}$ ,  $\chi_{Bp}$  and  $\chi_{Bn}$  we start from Eq. (17), for the particular case of *single electron* in the region subjected to the magnetic field  $B$  (*Copper rod*). In this case, we must substitute  $n_{r(t)}$  by  $n_{rcopper} = (\mu_{r(copper)} \sigma_{copper} / 4\pi\epsilon_0 f)^{\frac{1}{2}}$ ;  $n_l$  by  $1/V_e = 1/\frac{4}{3}\pi r_e^3$  ( $r_e$  is the electrons radius),  $S_f$  by  $(SSA_e)\rho_e V_e$  ( $SSA_e$  is the *specific surface area* for electrons in this case:  $SSA_e = \frac{1}{2} A_e / m_e = \frac{1}{2} A_e / \rho_e V_e = 2\pi r_e^2 / \rho_e V_e$ ),  $S_m$  by  $S_e = \pi r_e^2$ ,  $\xi$  by  $\phi_m = 2r_e$  and  $m_{i0(t)}$  by  $m_e$ . The result is

$$\chi_{Be} = \left\{ 1 - 2 \left[ \sqrt{1 + \frac{45.56\pi^2 r_e^4 n_{rcopper}^2 E^4}{\mu_0^2 m_e^2 c^4 f^4 \lambda^2}} - 1 \right] \right\} \quad (40)$$

Electrodynamics tells us that  $E_{rms} = vB_{rms} = (c/n_{r(copper)})B_{rms}$ , and Eq. (19) gives  $\lambda = \lambda_{mod} = (4\pi/\mu_{copper}\sigma_{copper}f)$ . Substitution of these expressions into Eq. (40) yields

$$\chi_{Be} = \left\{ 1 - 2 \left[ \sqrt{1 + \frac{45.56\pi^2 r_e^4 B_{rms}^4}{\mu_0^2 m_e^2 c^2 f^2}} - 1 \right] \right\} \quad (41)$$

Similarly, in the case of *proton* and *neutron* we can write that

$$\chi_{Bp} = \left\{ 1 - 2 \left[ \sqrt{1 + \frac{45.56\pi^2 r_p^4 B_{rms}^4}{\mu_0^2 m_p^2 c^2 f^2}} - 1 \right] \right\} \quad (42)$$

$$\chi_{Bn} = \left\{ 1 - 2 \left[ \sqrt{1 + \frac{45.56\pi^2 r_n^4 B_{rms}^4}{\mu_0^2 m_n^2 c^2 f^2}} - 1 \right] \right\} \quad (43)$$

The radius of *free electron* is  $r_e = 6.87 \times 10^{-14} m$  (See *Appendix A*) and the radius of *protons*



inside the atoms (nuclei) is  $r_p = 1.2 \times 10^{-15} m$ ,  $r_n \cong r_p$ , then we obtain from Eqs. (41) (42) and (43) the following expressions:

$$\chi_{Be} = \left\{ 1 - 2 \left[ \sqrt{1 + 8.49 \times 10^4 \frac{B_{rms}^4}{f^2}} - 1 \right] \right\} \quad (44)$$

$$\chi_{Bn} \cong \chi_{Bp} = \left\{ 1 - 2 \left[ \sqrt{1 + 2.35 \times 10^{-9} \frac{B_{rms}^4}{f^2}} - 1 \right] \right\} \quad (45)$$

Then, from Eq. (31) it follows that

$$m_e \chi_{Be} \cong 2m_p \chi_{Bp} \quad (46)$$

Substitution of Eqs. (44) and (45) into Eq. (46) gives

$$\frac{\left\{ 1 - 2 \left[ \sqrt{1 + 8.49 \times 10^4 \frac{B_{rms}^4}{f^2}} - 1 \right] \right\}}{\left\{ 1 - 2 \left[ \sqrt{1 + 2.35 \times 10^{-9} \frac{B_{rms}^4}{f^2}} - 1 \right] \right\}} = 3666.3 \quad (47)$$

For  $f = 0.1 Hz$ , we get

$$\frac{\left\{ 1 - 2 \left[ \sqrt{1 + 8.49 \times 10^6 B_{rms}^4} - 1 \right] \right\}}{\left\{ 1 - 2 \left[ \sqrt{1 + 2.35 \times 10^{-7} B_{rms}^4} - 1 \right] \right\}} = 3666.3 \quad (48)$$

whence we obtain

$$B_{rms} = 0.793 T \quad (49)$$

Consequently, Eq. (44) and (45) yields

$$\chi_{Be} = -3666.3 \quad (50)$$

and

$$\chi_{Bn} \cong \chi_{Bp} \cong 0.999 \quad (51)$$

In order to the forces  $F_e$  and  $F_p$  have *contrary direction* (such as occurs in the case, in which the nature of the electromotive force is electrical) we must have  $\chi_{Be} < 0$

and  $\chi_{Bn} \cong \chi_{Bp} > 0$  (See equations (28) (29) and (30)), i.e.,

$$\left\{ 1 - 2 \left[ \sqrt{1 + 8.49 \times 10^4 \frac{B_{rms}^4}{f^2}} - 1 \right] \right\} < 0 \quad (52)$$

and

$$\left\{ 1 - 2 \left[ \sqrt{1 + 2.35 \times 10^{-9} \frac{B_{rms}^4}{f^2}} - 1 \right] \right\} > 0 \quad (53)$$

This means that we must have

$$0.06\sqrt{f} < B_{rms} < 151.86\sqrt{f} \quad (54)$$

In the case of  $f = 0.1 Hz$  the result is

$$0.01T < B_{rms} < 48.02T \quad (55)$$

Let us now calculate the *current density through the Copper rod* (Fig. 4). According to Eq. (39) we have

$$j_e = \sigma_{copper} \left( \frac{m_e}{e} \right) \chi_{Be} \chi^{19} G \frac{M_{gs}}{r_0^2}$$

Since  $\sigma_{copper} = 5.8 \times 10^7 S/m$ ,  $\chi = -6.513$ ,  $\chi_{Be} = -3666.3$ ,  $M_{gs} = 3.04 \times 10^{-3} kg$  and  $r_0 = 9mm$ , we obtain

$$j_e = 8.77 \times 10^6 A/m^2$$

Given that  $S_\alpha = \pi \alpha^2 / 4 = 5.03 \times 10^{-5} m^2$  we get

$$i_s = j_e S_\alpha \cong 441 A$$

Note that this *Gravitational EMF source* is a *Current Source*. As we know, a Current Source is a device that keeps invariable the electric current between its terminals. So, if the source is connected to an external load, and the resistance of the load varies, then the own source will increase or decrease its output voltage in order to maintain invariable the value of the current in the circuit.

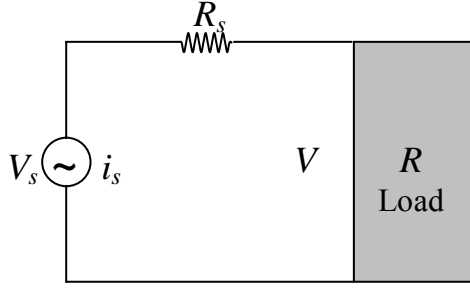


Fig. 3 – Current Source

The resistance of the Copper rod (Current Source) is

$$R_s = \left( \frac{x_B}{\sigma_{copper} S_\alpha} \right) = 3.42 \times 10^{-5} \Omega$$

Thus, the *dissipated power* by the Copper rod is

$$P_d = R_s i_s^2 \cong 6.6W \quad (56)$$

Based on Kirchhoff's laws we can express the electric voltage between the terminals of the Current Source,  $V_s$ , by means of the following relation (See Fig.3):

$$V_s = R_s i_s + V$$

where  $V$  is the voltage applied on the charge. Thus, the power of the Current Source is  $P_s = V_s i_s$ .

Considering that most of the electronics equipments requires  $V = 220V$  and that, here the current source has  $R_s i_s = 0.02V$ . Then, we obtain

$$V_s = R_s i_s + V \cong 220 V$$

Consequently, *the power of the current source* is given by

$$P_s = V_s i_s \cong 97kW \cong 130HP$$

Now it will be shown that this Gravitational EMF source can be *miniaturized*.

We start making  $x_B = 10mm$  and  $\xi = 0.5mm$ ;  $\alpha = 2mm$ ,  $d = 8mm$  and  $r_0 = 1.5mm$  (See Fig. 5). Thus, we have  $S_\alpha = 3.14 \times 10^{-6} m^2$ ;

$M_{gs} = 4.75 \times 10^{-5} kg$ . For  $f = 0.01Hz$  and  $S_\alpha = 3.14 \times 10^{-6} m^2$  Eq.(24) gives

$$\chi = \left\{ 1 - 2 \sqrt{1 + 1.822 \times 10^{-13} E_{(A)rms}^4} - 1 \right\} \quad (57)$$

For  $V_{A(rms)} = 24V$  and  $d = 8mm$  we get  $E_{(A)rms} = 3.0 \times 10^3 V/m$ , and Eq. (57) yields

$$\chi = -4.939$$

For  $V_{D(rms)} = 14.4V$  and  $d = 8mm$  we get  $E_{(D)rms} = 1.8 \times 10^3 V/m$  and  $\chi_d = 0.01$ .

Since  $\chi_{Be} = -3666.3$  and  $\sigma_{copper} = 5.8 \times 10^7 S/m$ , then the value of  $j_e$  is

$$j_e = \sigma_{copper} \left( \frac{m_e}{e} \right) \chi_{Be} \chi^{19} G \frac{M_{gs}}{r_0^2} = 2.6 \times 10^4 A/m^2$$

and

$$i_s = j_e S_\alpha \cong 0.082 A$$

The resistance of the Copper rod is

$$R_s = \left( \frac{x_B}{\sigma_{copper} S_\alpha} \right) = 5.49 \times 10^{-5} \Omega$$

Thus, the *dissipated power* by the Copper rod is

$$P_d = R_s i_s^2 \cong 3.7 \times 10^{-7} W$$

and

$$V_s = R_s i_s + V \cong V$$

For  $V = 24V$  we get

$$P_s = V_s i_s \cong 2W$$

This power is of the order of the power of the lithium batteries of usual mobiles. Note that the *miniaturized Gravitational EMF source* does not needs to be recharged and it occupies a volume (8mm x 40mm x 80mm. See Fig.5) similar to the volume of the mobile batteries.

Finally, for  $f = 0.01Hz$  Eq.(48) gives  $B = 0.25T$ .



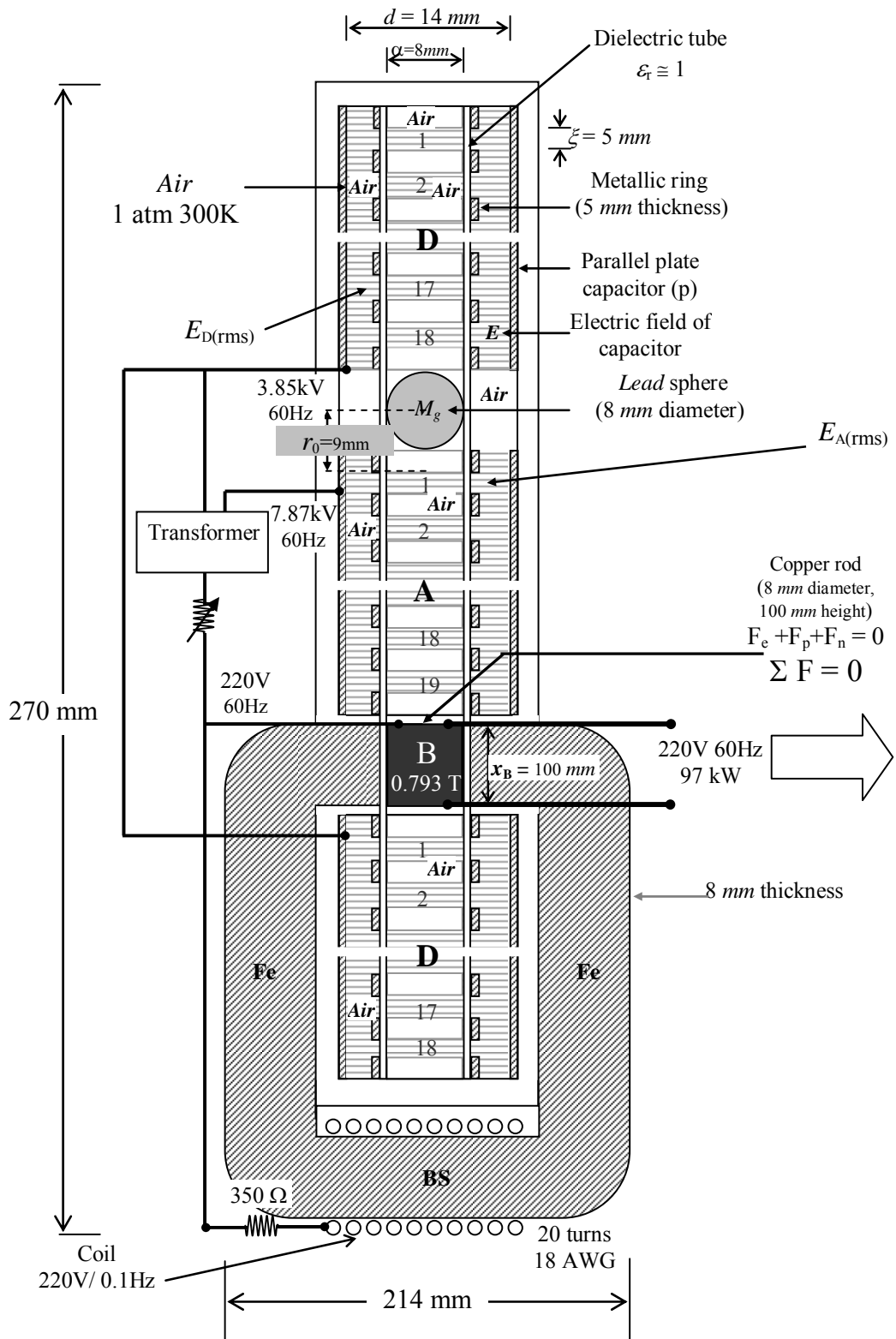


Fig. 4 – A Gravitational EMF Source (Developed from a process patented in July, 31 2008, PI0805046-5)

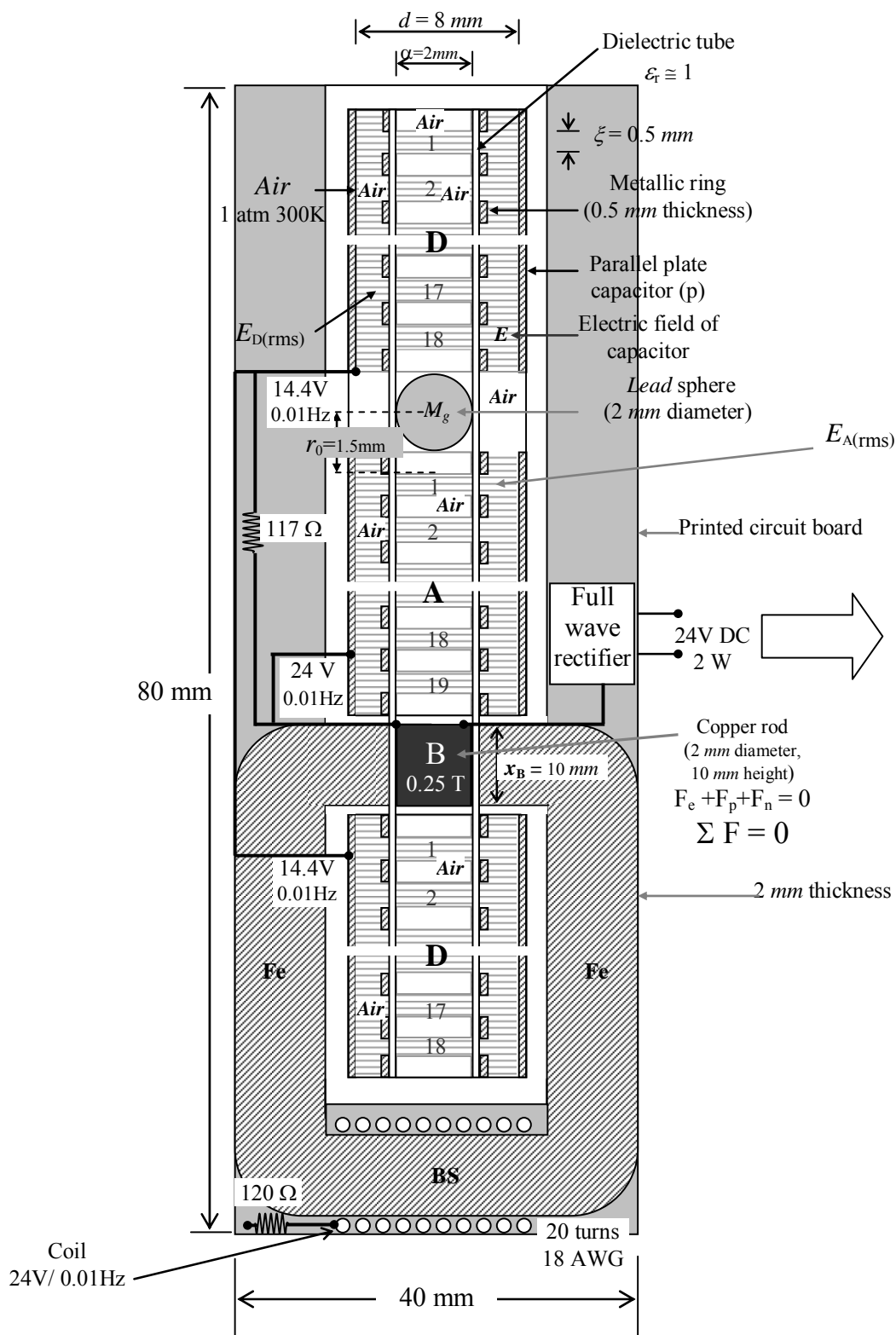


Fig. 5 – A miniaturized Gravitational EMF Source

## Appendix A: The “Geometrical Radii” of Electron and Proton

It is known that the frequency of oscillation of a simple spring oscillator is

$$f = \frac{1}{2\pi} \sqrt{\frac{K}{m}} \quad (A1)$$

where  $m$  is the inertial mass attached to the spring and  $K$  is the spring constant (in  $\text{N}\cdot\text{m}^{-1}$ ). In this case, the restoring force exerted by the spring is linear and given by

$$F = -Kx \quad (A2)$$

where  $x$  is the displacement from the equilibrium position.

Now, consider the gravitational force: For example, above the surface of the Earth, the force follows the familiar Newtonian function, i.e.,  $F = -GM_{g\oplus}m_g/r^2$ , where  $M_{g\oplus}$  the mass of Earth is,  $m_g$  is the gravitational mass of a particle and  $r$  is the distance between the centers. Below Earth's surface the force is linear and given by

$$F = -\frac{GM_{g\oplus}m_g}{R_{\oplus}^3} r \quad (A3)$$

where  $R_{\oplus}$  is the radius of Earth.

By comparing (A3) with (A2) we obtain

$$\frac{K}{m_g} = \frac{K}{\chi m} = \frac{GM_{g\oplus}}{R_{\oplus}^3} \left(\frac{r}{x}\right) \quad (A4)$$

Making  $x = r = R_{\oplus}$ , and substituting (A4) into (A1) gives

$$f = \frac{1}{2\pi} \sqrt{\frac{GM_{g\oplus}\chi}{R_{\oplus}^3}} \quad (A5)$$

In the case of an *electron* and a *positron*, we substitute  $M_{g\oplus}$  by  $m_{ge}$ ,  $\chi$  by  $\chi_e$  and  $R_{\oplus}$  by  $R_e$ , where  $R_e$  is the radius of electron (or positron). Thus, Eq. (A5) becomes

$$f = \frac{1}{2\pi} \sqrt{\frac{Gm_{ge}\chi_e}{R_e^3}} \quad (A6)$$

The value of  $\chi_e$  varies with the density of energy [1]. When the electron and the positron are distant from each other and the local density of energy is small, the value of  $\chi_e$  becomes very close to 1. However, when the electron and the positron are penetrating one another, the energy densities in each particle become very strong due to the proximity of their electrical charges  $e$  and, consequently, the value of  $\chi_e$  strongly increases. In order to calculate the value of  $\chi_e$  under these conditions ( $x = r = R_e$ ), we start from the expression of correlation between *electric charge*  $q$  and *gravitational mass*, obtained in a previous work [1]:

$$q = \sqrt{4\pi\epsilon_0 G} m_{g(\text{imaginary})} i \quad (A7)$$

where  $m_{g(\text{imaginary})}$  is the *imaginary* gravitational mass, and  $i = \sqrt{-1}$ .

In the case of *electron*, Eq. (A7) gives

$$\begin{aligned} q_e &= \sqrt{4\pi\epsilon_0 G} m_{g(\text{imaginary})} i = \\ &= \sqrt{4\pi\epsilon_0 G} (\chi_e m_{i0e(\text{imaginary})} i) = \\ &= \sqrt{4\pi\epsilon_0 G} \left(-\chi_e \frac{2}{\sqrt{3}} m_{i0e(\text{real})} i^2\right) = \\ &= \sqrt{4\pi\epsilon_0 G} \left(\frac{2}{\sqrt{3}} \chi_e m_{i0e(\text{real})}\right) = -1.6 \times 10^{-19} \text{C} \quad (A8) \end{aligned}$$

where we obtain

$$\chi_e = -1.8 \times 10^{21} \quad (A9)$$

This is therefore, the value of  $\chi_e$  increased by the strong density of energy produced by the electrical charges  $e$  of the two particles, under previously mentioned conditions.

Given that  $m_{ge} = \chi_e m_{i0e}$ , Eq. (A6) yields

$$f = \frac{1}{2\pi} \sqrt{\frac{G\chi_e^2 m_{i0e}}{R_e^3}} \quad (A10)$$

From Quantum Mechanics, we know that

$$hf = m_{i0} c^2 \quad (A11)$$

where  $h$  is the Planck's constant. Thus, in the case of  $m_{i0} = m_{i0e}$  we get

$$f = \frac{m_{i0e} c^2}{h} \quad (A12)$$

By comparing (A10) and (A12) we conclude that

$$\frac{m_{i0e} c^2}{h} = \frac{1}{2\pi} \sqrt{\frac{G\chi_e^2 m_{i0e}}{R_e^3}} \quad (A13)$$

Isolating the radius  $R_e$ , we get:

$$R_e = \left( \frac{G}{m_{i0e}} \right)^{\frac{1}{3}} \left( \frac{\chi_e h}{2\pi c^2} \right)^{\frac{2}{3}} = 6.87 \times 10^{-14} m \quad (A14)$$

Compare this value with the *Compton sized electron*, which predicts  $R_e = 3.86 \times 10^{-13} m$  and also with standardized result recently obtained of  $R_e = 4 - 7 \times 10^{-13} m$  [11].

In the case of *proton*, we have

$$\begin{aligned} q_p &= \sqrt{4\pi\epsilon_0 G} m_{gp(\text{imaginary})} i = \\ &= \sqrt{4\pi\epsilon_0 G} (\chi_p m_{i0p(\text{imaginary})} i) = \\ &= \sqrt{4\pi\epsilon_0 G} \left( -\chi_p \frac{2}{\sqrt{3}} m_{i0p(\text{real})} i^2 \right) = \\ &= \sqrt{4\pi\epsilon_0 G} \left( \frac{2}{\sqrt{3}} \chi_p m_{i0p(\text{real})} \right) = -1.6 \times 10^{-19} C \quad (A15) \end{aligned}$$

where we obtain

$$\chi_p = -9.7 \times 10^{17} \quad (A16)$$

Thus, the result is

$$R_p = \left( \frac{G}{m_{i0p}} \right)^{\frac{1}{3}} \left( \frac{\chi_p h}{2\pi c^2} \right)^{\frac{2}{3}} = 3.72 \times 10^{-17} m \quad (A17)$$

Note that these radii, given by Equations (A14) and (A17), are the radii of *free* electrons and *free* protons (when the particle and antiparticle (in isolation) penetrate themselves mutually).

Inside the atoms (nuclei) the radius of protons is well-known. For example, protons, as the hydrogen nuclei, have a radius given by  $R_p \cong 1.2 \times 10^{-15} m$  [12, 13]. The strong increase in respect to the value given by Eq. (A17) is due to the interaction with the electron of the atom.

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