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# Gravity Control by means of Modified Electromagnetic Radiation

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Here a new way for gravity control is proposed that uses electromagnetic radiation modified to have a smaller wavelength. It is known that when the velocity of a radiation is reduced its wavelength is also reduced. There are several ways to strongly reduce the velocity of an electromagnetic radiation. Here, it is shown that such a reduction can be done simply by making the radiation cross a conductive foil.

**Key words:** Modified theories of gravity, Experimental studies of gravity, Electromagnetic wave propagation.

PACS: 04.50.Kd , 04.80.-y, 41.20.Jb, 75.70.-i.

It was shown that the *gravitational mass*  $m_g$  and *inertial mass*  $m_i$  are correlated by means of the following factor [1]:

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

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

$$\begin{aligned} \frac{m_g}{m_{i0}} &= \left\{ 1 - 2 \left[ \sqrt{1 + \left( \frac{h/m_{i0}c}{\lambda} \right)^2} - 1 \right] \right\} \\ &= \left\{ 1 - 2 \left[ \sqrt{1 + \left( \frac{\lambda_0}{\lambda} \right)^2} - 1 \right] \right\} \end{aligned} \quad (2)$$

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

It is easily seen that  $m_g$  cannot be strongly reduced simply by using electromagnetic waves with wavelength  $\lambda$  because  $\lambda_0$  is very smaller than  $10^{-10} m$ . However, it is known that the wavelength of a radiation can be strongly reduced simply by strongly reducing its velocity.

There are several ways to reduce the velocity of an electromagnetic radiation. For example, by making light cross an *ultra cold atomic gas*, it is possible to reduce its velocity down to  $17m/s$  [2-7]. Here, it is shown that the velocity of an electromagnetic radiation can

be strongly reduced simply by making the radiation cross a conductive foil.

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 [8]

$$n_r = \frac{c}{v} = \sqrt{\frac{\epsilon_r \mu_r}{2} \left( \sqrt{1 + (\sigma/\omega\epsilon)^2} + 1 \right)} \quad (3)$$

If  $\sigma \gg \omega\epsilon$ ,  $\omega = 2\pi f$ , the Eq. (3) reduces to

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

Thus, the wavelength of the incident radiation becomes

$$\lambda_{\text{mod}} = \frac{v}{f} = \frac{c/f}{n_r} = \frac{\lambda}{n_r} = \sqrt{\frac{4\pi}{\mu f \sigma}} \quad (5)$$

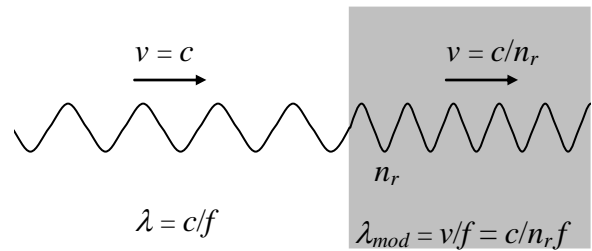


Fig. 1 – *Modified Electromagnetic Wave*. The wavelength of the electromagnetic wave can be strongly reduced, but its frequency remains the same.

Now consider a  $1GHz$  ( $\lambda \cong 0.3m$ ) radiation incident on *Aluminum foil* with  $\sigma = 3.82 \times 10^7 S/m$  and thickness  $\xi = 10.5 \mu m$ . According to Eq. (5), the *modified wavelength* is

$$\lambda_{\text{mod}} = \sqrt{\frac{4\pi}{\mu f \sigma}} = 1.6 \times 10^{-5} \text{ m} \quad (6)$$

Consequently, the wavelength of the 1GHz radiation *inside the foil* will be  $\lambda_{\text{mod}} = 1.6 \times 10^{-5} \text{ m}$  and not  $\lambda \cong 0.3 \text{ m}$ .

It is known that a radiation with frequency  $f$ , propagating through a material with electromagnetic characteristics  $\varepsilon$ ,  $\mu$  and  $\sigma$ , has the amplitudes of its waves decreased in  $e^{-1} = 0.37$  (37%), when it passes through a distance  $z$ , given by

$$z = \frac{1}{\omega \sqrt{\frac{1}{2} \varepsilon \mu \left( \sqrt{1 + (\sigma / \omega \varepsilon)^2} - 1 \right)}} \quad (7)$$

The radiation is totally absorbed at a distance  $\delta \cong 5z$  [8].

In the case of the 1GHz radiation propagating through the Aluminum foil Eq. (7), gives

$$z = \frac{1}{\sqrt{\pi \mu \sigma f}} = 2.57 \times 10^{-6} = 2.57 \mu\text{m} \quad (8)$$

Since the thickness of the Aluminum foil is  $\xi = 10.5 \mu\text{m}$  then, we can conclude that, practically all the incident 1GHz radiation is absorbed by the foil.

If the foil contains  $n$  atoms/ $\text{m}^3$ , 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 foil it reaches  $nS\xi$  atoms. If it incides on the total area of the foil,  $S_f$ , 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

$$n = \frac{N_0 \rho}{A} \quad (9)$$

where  $N_0 = 6.02 \times 10^{26} \text{ atoms/kmole}$  is the Avogadro's number ;  $\rho$  is the matter density of the foil (in  $\text{kg/m}^3$ ) and  $A$  is the atomic mass. In the case of the Aluminum ( $\rho = 2700 \text{ kg/m}^3$ ,  $A = 26.98 \text{ kmole}$ ) the result is

$$n_{\text{Al}} = 6.02 \times 10^{28} \text{ atoms/m}^3 \quad (10)$$

The *total number of photons* inciding on the foil is  $n_{\text{total photons}} = P/hf^2$ , where  $P$  is the

power of the radiation flux incident on the foil.

When an electromagnetic wave incides on the Aluminum foil, it strikes on  $N_f$  front atoms, where  $N_f \cong (nS_f)\phi_{\text{atom}}$ . Thus, the wave incides effectively on an area  $S = N_f S_a$ , where  $S_a = \frac{1}{4} \pi \phi_{\text{atom}}^2$  is the cross section area of one Aluminum atom. After these collisions, it carries out  $n_{\text{collisions}}$  with the other atoms of the foil (See Fig.2).

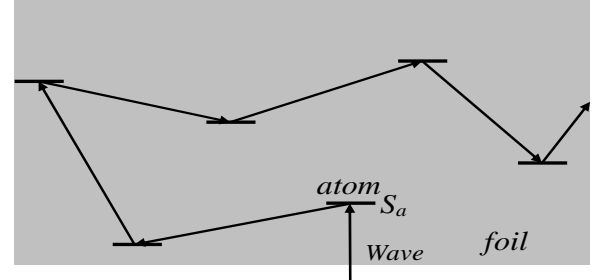


Fig. 2 – Collisions inside the foil.

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

$$N_{\text{collisions}} = N_f + n_{\text{collisions}} = nS\phi_{\text{atom}} + (nS\xi - nS\phi_{\text{atom}}) = nS\xi \quad (11)$$

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

$$D = \frac{P}{S} = \frac{P}{N_f S_a} \quad (12)$$

The same power density as a function of the power  $P_0$  radiated from the antenna, is given by

$$D = \frac{P_0}{4\pi r^2} \quad (13)$$

where  $r$  is the distance between the antenna and the foil. Comparing equations (12) and (13), we get

$$P = \left( \frac{N_f S_a}{4\pi r^2} \right) P_0 \quad (14)$$

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

$$n_1 = \frac{n_{\text{total photons}} N_{\text{collisions}}}{N} \quad (15)$$

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

$$\frac{m_g}{m_{i0}} = \left\{ 1 - 2 \left[ \sqrt{1 + \left[ (n_1 N) \frac{\lambda_0}{\lambda} \right]^2} - 1 \right] \right\} = \left\{ 1 - 2 \left[ \sqrt{1 + \left[ n_{total\ photons} N_{collisions} \frac{\lambda_0}{\lambda} \right]^2} - 1 \right] \right\} \quad (16)$$

Since Eq. (11) gives  $N_{collisions} = nS\xi$ , we get

$$n_{total\ photons} N_{collisions} = \left( \frac{P}{hf^2} \right) (nS\xi) \quad (17)$$

Substitution of Eq. (17) into Eq. (16) yields

$$\frac{m_g}{m_{i0}} = \left\{ 1 - 2 \left[ \sqrt{1 + \left[ \left( \frac{P}{hf^2} \right) (nS\xi) \frac{\lambda_0}{\lambda} \right]^2} - 1 \right] \right\} \quad (18)$$

Substitution of Eq. (14) into Eq. (18) gives

$$\frac{m_g}{m_{i0}} = \left\{ 1 - 2 \left[ \sqrt{1 + \left[ \left( \frac{N_f S_a P_0}{4\pi r^2 f^2} \right) \left( \frac{nS\xi}{m_{i0} c} \right) \frac{1}{\lambda} \right]^2} - 1 \right] \right\} \quad (19)$$

Substitution of  $N_f \cong (nS_f) \phi_{atom}$  and  $S = N_f S_a$  into Eq. (19) it reduces to

$$\frac{m_g}{m_{i0}} = \left\{ 1 - 2 \left[ \sqrt{1 + \left[ \left( \frac{n^3 S_f^2 S_a^2 \phi_{atom}^2 P_0 \xi}{4\pi r^2 m_{i0} c f^2} \right) \frac{1}{\lambda} \right]^2} - 1 \right] \right\} \quad (20)$$

In the case of a 20cm square Aluminum foil, with thickness  $\xi = 10.5 \mu m$ , we get  $m_{i0} = 1.1 \times 10^3 kg$ ,  $S_f = 4 \times 10^{-2} m^2$ ,  $\phi_{atom} \cong 10^{10} m^2$ ,  $S_a \cong 10^{20} m^2$ ,  $n = n_{Al} = 6.02 \times 10^{28} atoms / m^3$ , Substitution of these values into Eq. (20), gives

$$\frac{m_{g(Al)}}{m_{i0(Al)}} = \left\{ 1 - 2 \left[ \sqrt{1 + \left[ \left( 8.84 \times 10^{11} \frac{P_0}{r^2 f^2} \right) \frac{1}{\lambda} \right]^2} - 1 \right] \right\} \quad (21)$$

Thus, if the Aluminum foil is at a distance  $r = 1m$  from the antenna, and the power radiated from the antenna is  $P_0 = 32W$ , and the frequency of the radiation is  $f = 1GHz$  then Eq.(21) gives

$$\frac{m_{g(Al)}}{m_{i0(Al)}} = \left\{ 1 - 2 \left[ \sqrt{1 + \left[ \frac{2.8 \times 10^{-5}}{\lambda} \right]^2} - 1 \right] \right\} \quad (22)$$

In the case of the Aluminum foil and 1Ghz radiation, Eq. (6) shows that

$\lambda_{mod} = 1.6 \times 10^{-5} m$ . Thus, by substitution of  $\lambda$  by  $\lambda_{mod}$  into Eq. (22), we get the following expression

$$\frac{m_{g(Al)}}{m_{i0(Al)}} \cong -1 \quad (23)$$

Since  $\vec{P} = m_g \vec{g}$  then the result is

$$\vec{P}_{(Al)} = m_{g(Al)} \vec{g} \cong -m_{i0(Al)} \vec{g} \quad (24)$$

This means that, in the mentioned conditions, *the weight force of the Aluminum foil is inverted.*

It was shown [1] that there is an additional effect of *Gravitational Shielding* produced by a substance whose gravitational mass was reduced or made negative. This effect shows that just *above the substance* the gravity acceleration  $g_1$  will be reduced at the same ratio  $\chi_1 = m_g / m_{i0}$ , i.e.,  $g_1 = \chi_1 g$ , ( $g$  is the gravity acceleration *bellow* the substance). This means that above the Aluminum foil the gravity acceleration will be modified according to the following expression

$$g_1 = \chi_1 g = \left( \frac{m_{g(Al)}}{m_{i0(Al)}} \right) g \quad (25)$$

where the factor  $\chi_1 = m_{g(Al)} / m_{i0(Al)}$  will be given Eq. (21).

In order to check the theory presented here, we propose the experimental set-up shown in Fig. 3. The distance between the Aluminum foil and the antenna is  $r = 1m$ . The maximum output power of the 1GHz transmitter is 32W CW. A 10g body is placed above Aluminum foil, in order to check the *Gravitational Shielding Effect*. The distance between the Aluminum foil and the 10g body is approximately 10 cm. The alternative device to measure the weight variations of the foil and the body (including the *negative* values) uses two balances (200g / 0.01g) as shown in Fig. 3.

In order to check the effect of a *second* Gravitational Shielding above the first one (Aluminum foil), we can remove the 10g body, putting in its place a second Aluminum foil, with the same characteristics of the first one. The 10g body can be then placed at a

distance of 10cm above of the second Aluminum foil. Obviously, it must be connected to a third balance.

As shown in a previous paper [9] the gravity above the second Gravitational Shielding, in the case of  $\chi_2 = \chi_1$ , is given by

$$g_2 = \chi_2 g_1 = \chi_1^2 g \quad (26)$$

If a third Aluminum foil is placed above the second one, then the gravity above this foil is  $g_3 = \chi_3 g_2 = \chi_3 \chi_2 \chi_1 g = \chi_1^3 g$ , and so on.

In practice, *Multiple Gravitational Shieldings* can be constructed by inserting  $N$  several *parallel* Aluminum foils inside the dielectric of a parallel plate capacitor (See Fig. 4). In this case, the resultant capacity of the capacitor becomes  $C_r = C/N = \epsilon_r \epsilon_0 S_f / Nd$ , where  $S_f$  is the area of the Aluminum foils and  $d$  the distance between them;  $\epsilon_r$  is the relative permeability of the dielectric. By applying a voltage  $V_{rms}$  on the plates of the capacitor a current  $i_{rms}$  is produced through the Aluminum foils. It is expressed by  $i_{rms} = V_{rms} / X_C = 2\pi f C_r V_{rms}$ .

Since  $j_{rms} = \sigma E_{rms}$  and  $j_{rms} = i_{rms} / S_f$  we get  $E_{rms} = i_{rms} / S_f \sigma$ , which is the oscillating electric field through the Aluminum foils. By substituting this expression into Eq. (20), and considering that  $\lambda = \lambda_{mod} = (4\pi / \mu f \sigma)^{1/2}$  (Eq.6) and  $D = P_0 / 4\pi r^2 = n_r E_{rms}^2 / 2\mu_r \mu_0 c$ , where  $n_r = (\mu_r \sigma / 4\pi \epsilon_0 f)^{1/2}$  (Eq. 4), we obtain:

$$\chi = \left\{ 1 - 2 \left[ \sqrt{1 + \frac{n_{Al}^6 S_a^4 \phi_{atom}^4 i_{rms}^4}{64\pi^2 \rho_{Al}^2 c^2 S_f^2 \sigma_{Al}^2 f^4}} - 1 \right] \right\} \quad (27)$$

Since

$$i_{rms} = V_{rms} / X_C = 2\pi f C_r V_{rms} = 2\pi f (\epsilon_r \epsilon_0 S_f / Nd) V_{rms}$$

Then

$$\frac{i_{rms}}{f} = 2\pi (\epsilon_r \epsilon_0 S_f / Nd) V_{rms} \quad (28)$$

Substitution of this equation into Eq. (27) gives

$$\chi = \left\{ 1 - 2 \left[ \sqrt{1 + \frac{\pi^2 n_{Al}^6 S_a^4 \phi_{atom}^4 \epsilon_r^4 \epsilon_0^4 S_f^2 V_{rms}^4}{4\rho_{Al}^2 c^2 \sigma_{Al}^2 N^4 d^4}} - 1 \right] \right\} \quad (29)$$

Substitution of the known value of  $n_{Al} = 6.02 \times 10^{28} \text{ atoms/m}^3$ ,  $\phi_{atom} \cong 1 \times 10^{-10} \text{ m}$ ,

$S_a = 1/2 [4\pi(\phi_{atom}/2)^2] = 1/2 \pi \phi_{atom}^2 \cong 1 \times 10^{-20} \text{ m}^2$ ,  $\epsilon_r = 2.1$  (Teflon 24KV/mm, Short Time, 1.6 mm [10]),  $\rho_{Al} = 2700 \text{ kg.m}^{-3}$ , we get

$$\chi = \left\{ 1 - 2 \left[ \sqrt{1 + 1.4 \times 10^{-29} \frac{S_f^2}{N^4} \left( \frac{V_{rms}}{d} \right)^4} - 1 \right] \right\} \quad (30)$$

Note that, based on the equation above, it is possible to create a device for moving very heavy loads such as large monoliths, for example.

Imagine a large monolith on the Earth's surface. If we place below the monolith some sets with *Multiple Gravitational Shieldings* (See Fig.4), the value of the gravity acceleration above each set of Gravitational Shieldings becomes

$$g_R = \chi^\eta g \quad (31)$$

where  $\eta$  is the number of Gravitational Shieldings in each set.

Since we must have  $V_{rms}/d < 24 \text{ KV/mm}$  (dielectric strength of Teflon) [10] then, for  $d = 1.6 \text{ mm} \rightarrow V_{rms} < 38.4 \text{ KV}$ . For  $V_{rms} = 37 \text{ KV}$ ,  $d = 1.6 \text{ mm}$ ,  $S_f = 2.7 \text{ m}^2$ ,  $N = 2$  and  $\eta = 3$  Eq. (30) gives  $\chi = -0.36$  and Eq. (31) shows that  $g_R = \chi^3 g \cong -0.46 \text{ m/s}^2$ . The sign (-) shows that *the gravity acceleration above the six sets of Gravitational Shieldings becomes repulsive* in respect to the Earth. Thus, by controlling the value of  $\chi$  it is possible to make the total mass of the monolith slightly negative in order to the monolith can float and, in this way, it can be displaced and carried to anywhere with ease.

Considering the dielectric strength of known dielectrics, we can write that  $(V_{rms}/d)_{max} < 200 \text{ KV/mm}$ . Thus, for a single capacitor ( $N = 1$ ) Eq. (30) gives

$$\chi = \left\{ 1 - 2 \left[ \sqrt{1 + (\ll 2.2 \times 10^4 S_f^2)} - 1 \right] \right\} \quad (31)$$

The Gravitational Shielding effect becomes negligible for  $\chi < 0.01$  (variation smaller than 1% in the gravitational mass). Thus, considering Eq. (31), we can conclude that *the Gravitational Shielding effect becomes significant only for  $S_f \gg 10^{-2} \text{ m}^2$* . Possibly this is why it was not yet detected.

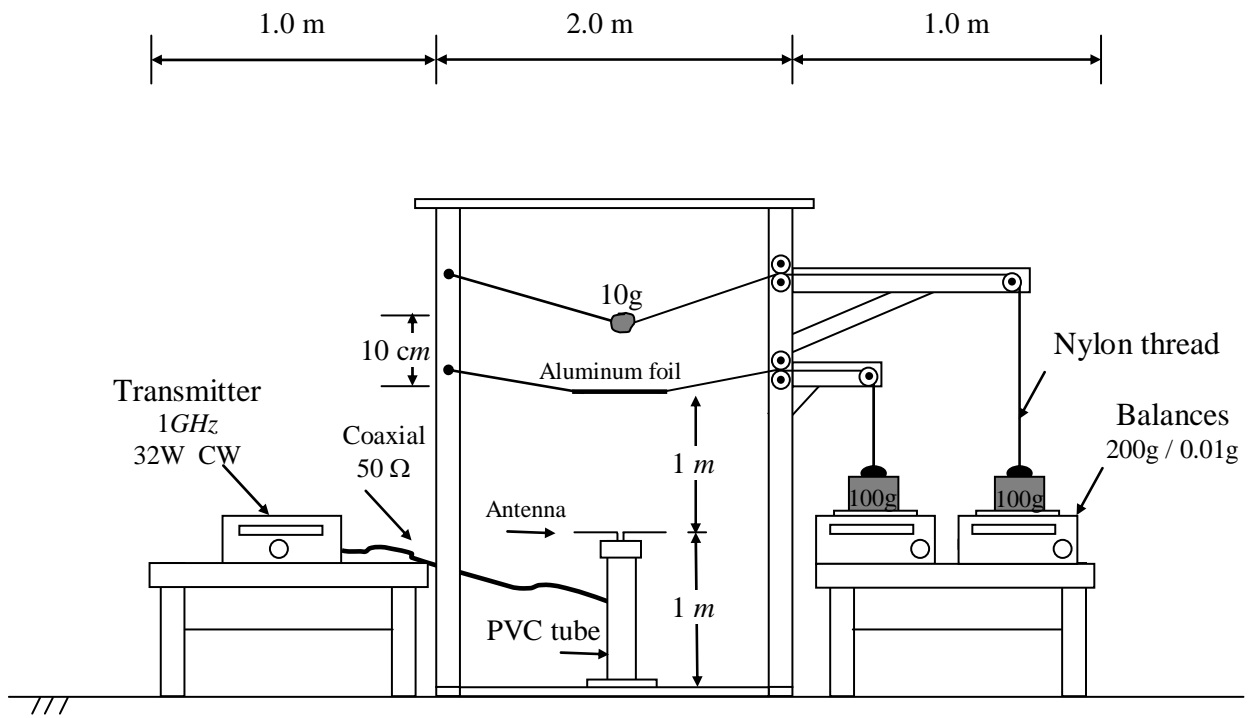


Fig. 3 – Experimental Set-up

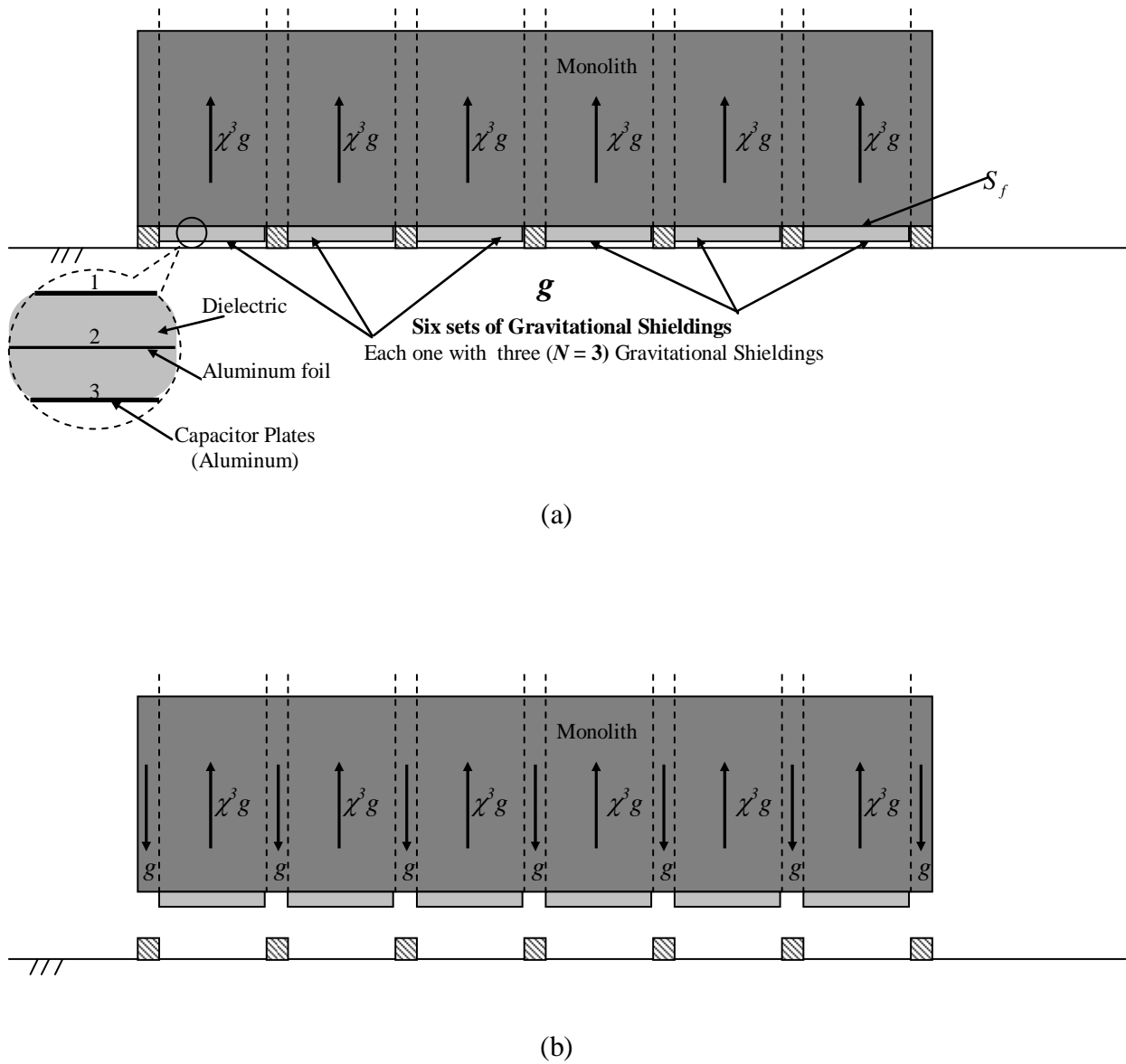


Fig. 4 – System with six sets of Gravitational Shieldings for moving very heavy loads. For  $V_{rms} = 37KV$ ,  $d = 1.6mm$ ,  $S_f = 2.7m^2$ ,  $N = 2$  and  $\eta = 3$  Eq. (30) gives  $\chi = -0.36$  and Eq. (31) shows that  $g_R = \chi^3 g \cong -0.46m/s^2$ . The sign (-) shows that the gravity acceleration above the six sets of Gravitational Shieldings becomes repulsive in respect to the Earth. Thus, by controlling the value of  $\chi$  it is possible to make the total mass of the monolith slightly negative in order to the monolith can float and, in this way, it can be displaced and carried to anywhere with ease.

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