# Gravity Control by means of Modified Electromagnetic Radiation

**Fran De Aquino**
Maranhao State University, Physics Department, S.Luis/MA, Brazil.


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]:

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

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

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

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

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 $\varepsilon_r$, 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]

$$n_r = \frac{c}{v} = \sqrt{\frac{\varepsilon_r\mu_r}{2}\left(\sqrt{1+(\sigma/\omega\varepsilon)^2}+1\right)} \qquad (3)$$

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

$$n_r = \sqrt{\frac{\mu_r\sigma}{4\pi\varepsilon_0 f}} \qquad (4)$$

Thus, the wavelength of the incident radiation becomes

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

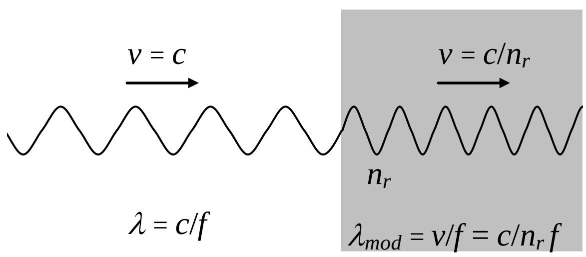


Fig. 1 – *Modified Electromagnetic Wave*. The wavelength of the electromagnetic wave can be strongly reduced, but its frequency remains the same.

Now consider a $1GHz\,(\lambda \cong 0.3m)$ radiation incident on *Aluminum foil* with $\sigma = 3.82\times10^{7}\,S/m$ and thickness $\xi = 10.5\mu m$. According to Eq. (5), the *modified wavelength* is

$$\lambda_{\text{mod}} = \sqrt{\frac{4\pi}{\mu f \sigma}} = 1.6\times10^{-5}\,m \qquad (6)$$

Consequently, the wavelength of the $1GHz$ radiation *inside the foil* will be $\lambda_{\text{mod}} = 1.6\times10^{-5}\,m$ and not $\lambda \cong 0.3m$.

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

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

The radiation is totally absorbed at a distance δ≅5*z* [8].

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

$$z = \frac{1}{\sqrt{\pi\mu\sigma f}} = 2.57\times10^{-6} = 2.57\mu m \qquad (8)$$

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

If the foil 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 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

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

where $N_0 = 6.02\times10^{26}\,atoms/kmole$ is the Avogadro's number ; $\rho$ is the matter density of the foil (in *kg/m*$^3$) and $A$ is the atomic mass. In the case of the *Aluminum* $\left(\rho = 2700kg/m^{3}, A = 26.98kmole\right)$ the result is

$$n_{Al} = 6.02\times10^{28}\,atoms/m^{3} \qquad (10)$$

The *total number of photons* inciding on the foil is $n_{total\ photons} = P/hf^{2}$, 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 $N_f \cong (nS_f)\phi_{atom}$. Thus, the wave incides effectively on an area $S = N_f S_a$, where $S_a = \frac{1}{4}\pi\phi_{atom}^{2}$ is the cross section area of one Aluminum atom. After these collisions, it carries out $n_{collisions}$ with the other atoms of the foil (See Fig.2).

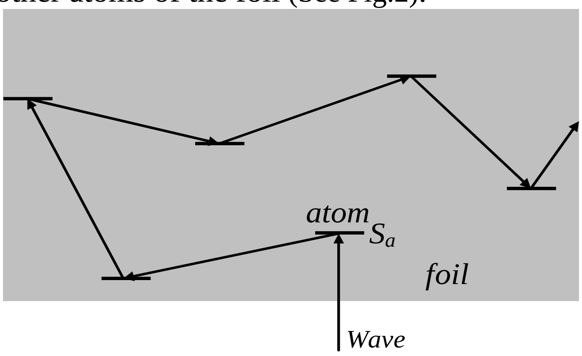


Fig. 2 – *Collisions inside the foil.*

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

$$N_{collisions} = N_f + n_{collisions} = nS\phi_{atom} + \left(nS\xi - nS\phi_{atom}\right) = $$
$$= nS\xi \qquad (11)$$

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

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

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

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

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

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

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

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

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

$$\frac{m_g}{m_{i0}}=\left\{1-2\left[\sqrt{1+\left[(n_1 N)\frac{\lambda_0}{\lambda}\right]^2}-1\right]\right\}=$$

$$=\left\{1-2\left[\sqrt{1+\left[n_{total\ photons}N_{collisions}\frac{\lambda_0}{\lambda}\right]^2}-1\right]\right\} \qquad (16)$$

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

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

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

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

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

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

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

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

In the case of a 20cm square Aluminum foil, with thickness $\xi=10.5\mu m$, we get $m_{i0}=1.1\times10^{-3}kg$, $S_f=4\times10^{-2}m^2$, $\phi_{atom}\cong10^{-10}m^2$ $S_a\cong10^{-20}m^2$, $n=n_{Al}=6.02\times10^{28}\,atoms/m^3$, Substitution of these values into Eq. (20), gives

$$\frac{m_{g(Al)}}{m_{i0(Al)}}=\left\{1-2\left[\sqrt{1+\left[\left(8.84\times10^{11}\frac{P_0}{r^2 f^2}\right)\frac{1}{\lambda}\right]^2}-1\right]\right\} \qquad (21)$$

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

$$\frac{m_{g(Al)}}{m_{i0(Al)}}=\left\{1-2\left[\sqrt{1+\left[\frac{2.8\times10^{-5}}{\lambda}\right]^2}-1\right]\right\} \qquad (22)$$

In the case of the Aluminum foil and $1Ghz$ radiation, Eq. (6) shows that $\lambda_{mod}=1.6\times10^{-5}m$. Thus, by substitution of $\lambda$ by $\lambda_{mod}$ into Eq. (22), we get the following expression

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

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

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

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

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

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

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

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.

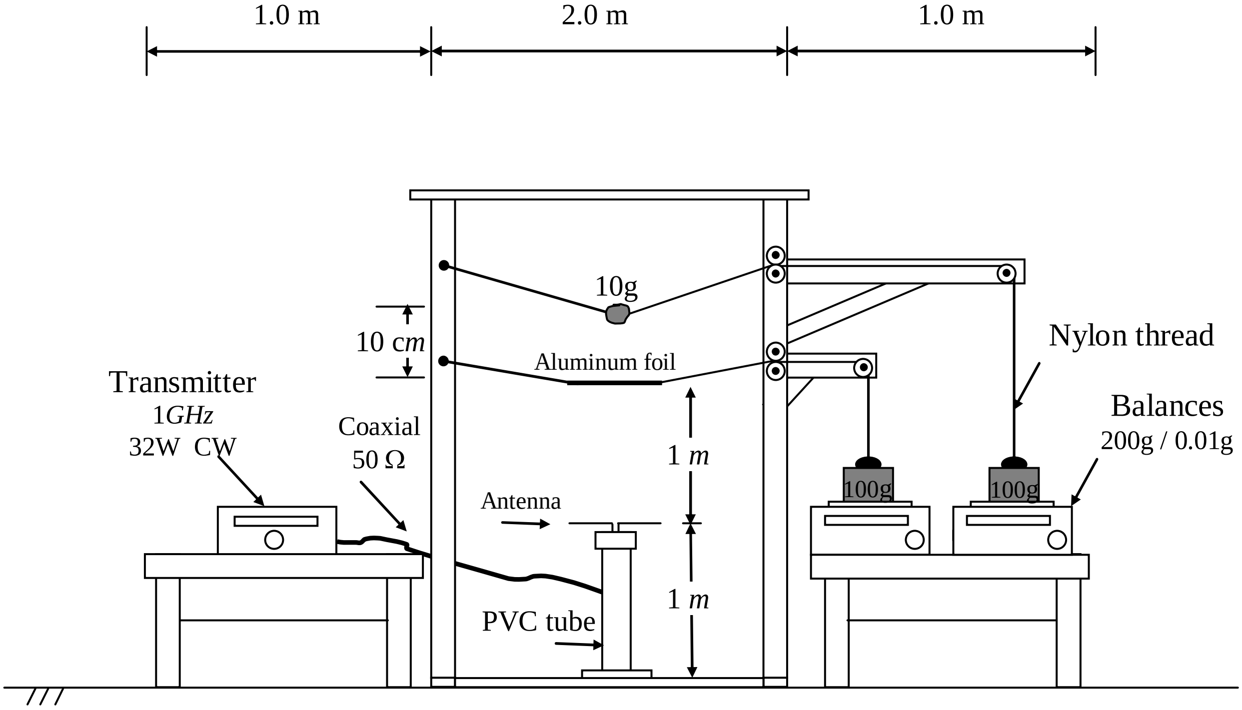


Fig. 3 – Experimental Set-up

# References


[1] De Aquino, F. (2010) *Mathematical Foundations of the Relativistic Theory of Quantum Gravity*, Pacific Journal of Science and Technology, **11** (1), pp. 173-232.

[2] Hau, L.V., et al., (1999) Nature, 397, 594-598.

[3] Kash, M. M. et al., (1999) Phys. Rev. Lett. 82, 5229.

[4] Budiker, D. et al., (1999) Phys. Rev. Lett. 83, 1767.

[5] Liu, Ch. et al., (2001) Nature 409, 490.

[6] Dutton, Z., et al., (2001) Science 293, 663.

[7] Turukhin, A. V., et al., (2002) Phys. Rev. Lett. 88, 023602

[8] Quevedo, C. P. (1977) *Eletromagnetismo*, McGraw-Hill, p. 270.

[9] De Aquino, F. (2010) *Gravity Control by means of Electromagnetic Field through Gas at Ultra-Low Pressure*, Pacific Journal of Science and Technology, **11**(2) November 2010, pp.178-247.