Experimental set-up to check the decreasing of the Gravitational Mass in *Metallic Discs* subjected to an alternating voltage of extremely low frequency.

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A very simple experimental arrangement is proposed here in order to check the decreasing of the *Gravitational Mass* in Metallic Discs subjected to an alternating voltage of extremely low frequency (ELF).

Key words: Gravitational Mass, Gravitational mass and inertial mass, Gravitational Interaction.

INTRODUCTION

In a previous paper [1] we shown that there is a correlation between the gravitational mass, m_g, and the rest inertial mass m_{i0}, which is given by

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

where Δp is the variation in the particle's *kinetic momentum*; U is *the electromagnetic energy absorbed or emitted by the particle;* n_r is the index of refraction of the particle; W is the density of energy on the particle (J/kg); ρ is the matter density (kg/m^3) and c is the speed of light.

The *instantaneous values* of the density of electromagnetic energy in an *electromagnetic* field can be deduced from Maxwell's equations and has the following expression

$$W = \tfrac{1}{2}\varepsilon E^2 + \tfrac{1}{2}\mu H^2 \qquad (2)$$

where $E = E_m \sin \omega t$ and $H = H \sin \omega t$ are the *instantaneous values* of the electric field and the magnetic field respectively.

It is known that $B = \mu H$, $E/B = \omega/k_r$ [2] and

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

where k_r is the real part of the *propagation vector* $\vec{k}$ (also called *phase constant*); $k = \left|\vec{k}\right| = k_r + ik_i$; ε , μ and σ, are the electromagnetic characteristics of the medium in which the incident (or emitted) radiation is propagating ($\varepsilon = \varepsilon_r\varepsilon_0$; $\varepsilon_0 = 8.854\times10^{-12}F/m$; $\mu = \mu_r\mu_0$ where $\mu_0 = 4\pi\times10^{-7}H/m$). From Eq. (3), we see that the *index of refraction* $n_r = c/v$ is given by

$$n_r = \frac{c}{v} = \sqrt{\frac{\varepsilon_r\mu_r}{2}\left(\sqrt{1+(\sigma/\omega\varepsilon)^2} + 1\right)} \qquad (4)$$

Equation (3) shows that $\omega/\kappa_r = v$. Thus, $E/B = \omega/k_r = v$, i.e.,

$$E = vB = v\mu H$$

Then, Eq. (2) can be rewritten as follows

$$W = \tfrac{1}{2}\varepsilon E^2 + \tfrac{1}{2}\mu\left(\frac{E}{v\mu}\right)^2 = $$
$$= \tfrac{1}{2}\varepsilon E^2 + \tfrac{1}{2}\left(\frac{1}{v^2\mu}\right)E^2 = $$
$$= \tfrac{1}{2}\left(\frac{1}{v^2\mu}\right)E^2 + \tfrac{1}{2}\left(\frac{1}{v^2\mu}\right)E^2 = $$
$$= \left(\frac{1}{v^2\mu}\right)E^2 = \left(\frac{c^2}{v^2\mu c^2}\right)E^2 = $$
$$= \left(\frac{n_r^2}{\mu c^2}\right)E^2 \qquad (5)$$

For $\sigma >> \omega\varepsilon$, Eq. (3) gives

$$n_r^2 = \frac{c^2}{v^2} = \frac{\mu\sigma}{2\omega}c^2 \qquad (6)$$

Substitution of Eq. (6) into Eq. (5) gives

$$W = (\sigma/2\omega)E^2 \qquad (7)$$

Substitution of Eq. (7) into Eq. (1), yields

$$m_g = \left\{1 - 2\left[\sqrt{1 + \frac{\mu}{c^2}\left(\frac{\sigma}{4\pi f}\right)^3\frac{E^4}{\rho^2}} - 1\right]\right\}m_{i0} = $$
$$= \left\{1 - 2\left[\sqrt{1 + \left(\frac{\mu_0}{64\pi^3c^2}\right)\left(\frac{\mu_r\sigma^3}{\rho^2 f^3}\right)E^4} - 1\right]\right\}m_{i0} = $$
$$= \left\{1 - 2\left[\sqrt{1 + 7.032\times10^{-27}\left(\frac{\mu_r\sigma^3}{\rho^2 f^3}\right)E^4} - 1\right]\right\}m_{i0} \qquad (8)$$

Note that if $E = E_m \sin \omega t$ .Then, the average value for E^2 is equal to $\frac{1}{2}E_m^2$ because E varies sinusoidaly (E_m is the maximum value for E). On the other hand, we have $E_{rms} = E_m / \sqrt{2}$. Consequently, we can change E^4 by E_{rms}^4 , and the Eq. (8) can be rewritten as follows

$$m_g = \left\{1 - 2\left[\sqrt{1 + 7.032\times10^{-27}\left(\frac{\mu_r\sigma^3}{\rho^2 f^3}\right)E_{rms}^4} - 1\right]\right\}m_{i0} \quad (9)$$

The *Ohm's vectorial Law* tells us that $j_{rms} = \sigma E_{rms}$. Thus, we can write Eq. (9) in the following form:

$$m_g = \left\{1 - 2\left[\sqrt{1 + 7.032\times10^{-27}\frac{\mu_r j_{rms}^4}{\sigma\rho^2 f^3}} - 1\right]\right\}m_{i0} \quad (10)$$

where $j_{rms} = j/\sqrt{2}$ [2]. Since

$$j = \frac{i}{S} = \frac{V/R}{S} = \frac{V}{RS} = \frac{V}{(l/\sigma S)S} = \sigma\left(\frac{V}{l}\right) \quad (11)$$

Then, we can write that

$$j_{rms} = \frac{\sigma}{\sqrt{2}}\left(\frac{V}{l}\right) \quad (12)$$

By substitution of Eq. (12) into Eq.(10), we get

$$\chi = \frac{m_g}{m_{i0}} = \left\{1 - 2\left[\sqrt{1 + 1.758\times10^{-27}\left(\frac{\mu_r\sigma^3}{\rho^2}\right)\frac{(V/l)^4}{f^3}} - 1\right]\right\} \quad (13)$$

In this paper it is proposed a very simple experimental set-up to check the decreasing of the Gravitational Mass in *Metallic Discs* subjected to an alternating voltage V of extremely low frequency (See Fig.2).

SUGGESTED EXPERIMENT

Consider the experimental set-up showed in Fig.2. Basically it is an electrical transformer where the secondary winding is coupled to a metallic disc with l *thickness*, relative permeability μ_r , electrical conductivity σ and mass density ρ ; the electrical resistance of the disc is R_d , and it is subjected to an alternating voltage V with frequency f , as showed in Fig.2.

Since the number of turns in both windings is the same, i.e., $N_p = N_S = N$, then we have that $V_P/V_S = N_P/N_S = 1$, i.e., $V_P = V_S = V$. Since $a^2 = Z_P/Z_S = (N_P/N_S)^2$, then we have $Z_P = Z_S$. On the other hand, since $V_P i_P = V_S i_S$ then we have that $i_P = i_S$ (i_S is the current through the secondary inductor; i_P is the current through the primary inductor). Since $V = 220volts - R_r i_P$ (See Fig.2), then $i_P = (220 - V)/R_r$; R_r is the electrical resistance of the potentiometer. Therefore, we can write that

$$i_P = \frac{220 - V}{R_r} \quad (15)$$

On the other hand, we can write that

$$i_P = i_S = V_S/Z_S = V_P/Z_P \quad (16)$$

Where $V_P = V_S = V$ and $Z_S = Z_P \cong X_L$. Thus, we get

$$i_P = V/X_L \quad (17)$$

By comparing Eq.(17) with Eq.(15), we obtain

$$V = \frac{220}{1 + \frac{R_r}{X_L}} \quad (18)$$

where $X_L = 2\pi f L$; L is given by [3].

$$L = \frac{\mu_0 N^2 A}{(l_B - 0.45d)} \qquad (l_B >> d) \quad (19)$$

In the equation above N is the number of turns in each winding, A is the cross-sectional area of the core, l_B is the length of the coil and d is the diameter of the core (See Fig 1).

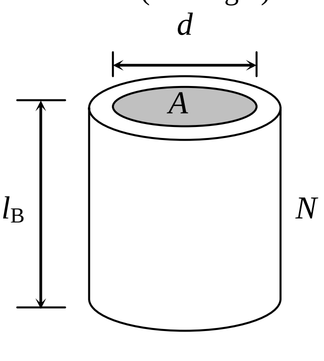

Fig. 1 – Inductance L of a coil of wire

Note that, in the Eq.(18), if $R_r = 0$ then $V = 220volts$. On the other hand, for $R_r > X_L$ the result is $V < 220volts$. In addition note that the maximum value of i_P must be smaller than the maximum current, $i_{\max}$, supported by the conductor used in the secondary winding*, i.e.,

$$i_P = V/X_L < i_{\max} \qquad (20)$$

As higher the value of X_L the lower the current intensity across the secondary. Since in the set-up shown in Fig.2 we have $V_{\max} = 220 volts$, then we concluded that

$$X_L > \frac{220}{i_{\max}} \qquad (21)$$

Now, consider the case in which the metallic disc is made *iron* ($\mu_r = 250$†, $\sigma = 1.05 \times 10^7 S/m$, $\rho = 7874\ kg/m^3$) with $2mm$ thickness, subjected to a voltage V with frequency $f = 60Hz$. In this case the Eq. (13) gives

$$\chi = \frac{m_{g(disc)}}{m_{i0(disc)}} = \left\{1 - 2\left[\sqrt{1 + 2.37\times10^{-6}V^4} - 1\right]\right\} \qquad (22)$$

Equation (18) tells us that if, for example, $R_r = 12X_L$, then the value of V reduces to $V = 16.9 volts$. In this case, Eq. (22) shows that the *gravitational mass* of the disc, $m_{g(disc)}$, reduces to

$$m_{g(disc)} \cong 0.8 m_{i0(disc)} \qquad (23)$$

This means that the initial *gravitational* mass of the disc, measured by the balance $\left(m_{g(disc)} = P_{disc}/g = m_{i0(disc)}\right)$, is reduced of about 20%.

On the other hand, if $V = 50 volts$, the *gravitational mass* of the disc, according to Eq. (22), is then strongly reduced becoming *negative* and given by

$$m_{g(disc)} \cong -4.9 m_{i0(disc)} \qquad (24)$$

In the case of an *Aluminum* disc ($\mu_r = 1, \sigma = 3.5\times10^7 S/m$, $\rho = 2700 kg/m^3$), with $2mm$ thickness, the Eq. (13) gives

$$\chi = \frac{m_{g(disc)}}{m_{i0(disc)}} = \left\{1 - 2\left[\sqrt{1 + 2.99\times10^{-6}V^4} - 1\right]\right\} \qquad (25)$$

Compare this equation with Eq. (22). Note that they supply close results for the same values of V.

If $V = 50 volts$ the *gravitational mass* of the disc, according to Eq. (25), will be given by

$$m_{g(disc)} \cong -5.8 m_{i0(disc)} \qquad (26)$$

In the case of $V = 220 volts$ $(R_r = 0)$ the *gravitational mass* of the disc becomes

$$m_{g(disc)} \cong -164.4 m_{i0(disc)} \qquad (27)$$

Obviously, the mass of the disc holder, m_{holder}, shown in the Fig.2, must be greater than this value, i.e., $m_{holder} > 164.4 m_{i0(disc)}$. This value defines then the weighing capacity of the balance shown in Fig.2.

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* In the case of wire #12 AWG, $i_{\max} \cong 10A$.

† Without current in the coil.

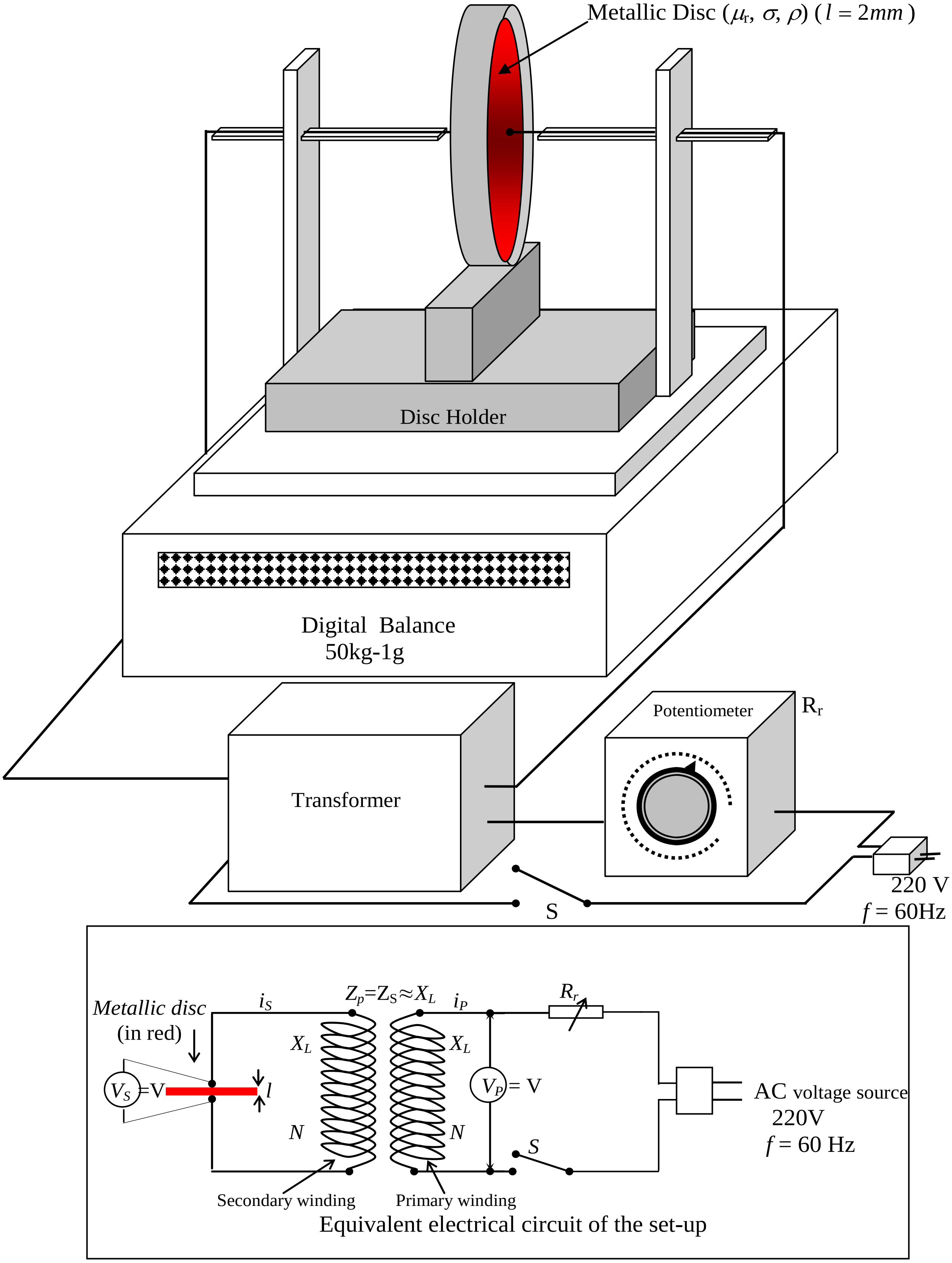

Fig. 2 - Experimental set-up to check the Gravitational Mass of *metallic discs* subjected to alternating voltage V with frequency $f = 60Hz$.

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