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Decreasing of the Gravitational Mass in materials with *Extremely High Permeability* subjected to an Alternating Magnetic Field of Extremely Low Frequency.

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Here we propose a very simple experiment in order to check the decreasing of the *Gravitational Mass* in materials with *Extremely High Permeability* subjected to an Alternating Magnetic Field of Extremely Low Frequency.

Key words: Gravitational Mass, Magnetic Field of Extremely Low Frequency, Extremely High Permeability.

INTRODUCTION

In this paper it is proposed a very simple experimental set-up in order to check the decreasing of the *Gravitational Mass* in materials with *Extremely High Permeability* subjected to an Alternating Magnetic Field of Extremely Low Frequency.

THEORY

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

$$\begin{aligned} \chi = \frac{m_g}{m_{i0}} &= \left\{ 1 - 2 \left[\sqrt{1 + \left(\frac{\Delta p}{m_{i0} c} \right)^2} - 1 \right] \right\} = \\ &= \left\{ 1 - 2 \left[\sqrt{1 + \left(\frac{U n_r}{m_{i0} c^2} \right)^2} - 1 \right] \right\} = \\ &= \left\{ 1 - 2 \left[\sqrt{1 + \left(\frac{W n_r}{\rho c^2} \right)^2} - 1 \right] \right\} \end{aligned} \quad (1)$$

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

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

where $E = E_m \sin \omega t$ and $H = H_m \sin \omega t$ 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

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

where k_r is the real part of the *propagation vector* \vec{k} (also called *phase constant*); $k = |\vec{k}| = k_r + ik_i$; ε , μ and σ , are the electromagnetic characteristics of the medium in which the incident (or emitted) radiation is propagating ($\varepsilon = \varepsilon_r \varepsilon_0$; $\varepsilon_0 = 8.854 \times 10^{-12} F/m$; $\mu = \mu_r \mu_0$ where $\mu_0 = 4\pi \times 10^{-7} H/m$; σ is the electrical conductivity in S/m). From Eq. (3), we see that the *index of refraction* $n_r = c/v$ is given by

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

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

$$E = vB = v\mu H \quad (5)$$

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

$$\begin{aligned} W &= \frac{1}{2} \varepsilon v^2 \mu^2 H^2 + \frac{1}{2} \mu H^2 = \\ &= \frac{1}{2} \mu H^2 (\varepsilon v^2 \mu) + \frac{1}{2} \mu H^2 = \mu H^2 \end{aligned} \quad (6)$$

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

$$n_r^2 = \frac{c^2}{v^2} = \frac{\mu\sigma}{2\omega} c^2 \quad (7)$$

Substitution of Eqs. (6) and (5) into Eq. (1) gives

$$\chi = \frac{m_g}{m_{i0}} = \left\{ 1 - 2 \left[\sqrt{1 + \left(\frac{\mu^3 \sigma}{4\pi f \rho^2 c^2} \right) H^4} - 1 \right] \right\} \quad (8)$$

Note that if $H = H_m \sin \omega t$. Then, the average value for H^2 is equal to $\frac{1}{2} H_m^2$ because H varies sinusoidally (H_m is the maximum value for H). On the other hand, we have $H_{rms} = H_m / \sqrt{2}$.

Consequently, we can change H^4 by H_{rms}^4 , and the Eq. (8) can be rewritten as follows

$$\chi = \frac{m_g}{m_{i0}} = \left\{ 1 - 2 \left[\sqrt{1 + \left(\frac{\mu^3 \sigma}{4\pi f \rho^2 c^2} \right) H_{rms}^4} - 1 \right] \right\} \quad (9)$$

Note that in this equation the value of the magnetic permeability, μ , is raised to the third power. This means that the decreasing of the Gravitational Mass in materials with *Extremely High Permeability* ($\mu_r > 100,000$; $\mu = \mu_r \mu_0$; $\mu_0 = 4\pi \times 10^{-7} H/m$) subjected to an Alternating Magnetic Field (H_{rms}) of *Extremely Low Frequency* ($f < 100Hz$) can be easily observed experimentally.

SUGGESTED EXPERIMENT

Let us consider some known materials with Extremely High Permeability. For example: Metglas, Supermalloy and pure Iron, which the following characteristics [3, 4]:

Metglas (Metglas 2714A, annealed)

$$\mu_r = 1,000,000 \text{ At } 0.5 \text{ T}$$

$$\sigma = 7.04 \times 10^5 \text{ S/m}$$

$$\rho = 7590 \text{ kg.m}^{-3}$$

Supermalloy (annealed in H controlled cooling)

$$\mu_r = 1,000,000 \text{ At } 0.7 \text{ T}$$

$$\sigma = 1.6 \times 10^6 \text{ S/m}$$

$$\rho = 8770 \text{ kg.m}^{-3}$$

Iron (99.95% pure Fe annealed in H)

$$\mu_r = 200,000$$

$$\sigma = 1.05 \times 10^7 \text{ S/m}$$

$$\rho = 7600 \text{ kg.m}^{-3}$$

For these materials Eq. (9), respectively, gives

$$\chi_{Metglas} = \left\{ 1 - 2 \left[\sqrt{1 + 2.1 \times 10^{-20} \left(\frac{H_{rms}^4}{f} \right)} - 1 \right] \right\} \quad (10)$$

$$\chi_{Supermalloy} = \left\{ 1 - 2 \left[\sqrt{1 + 3.6 \times 10^{-20} \left(\frac{H_{rms}^4}{f} \right)} - 1 \right] \right\} \quad (11)$$

$$\chi_{Iron} = \left\{ 1 - 2 \left[\sqrt{1 + 2.5 \times 10^{-21} \left(\frac{H_{rms}^4}{f} \right)} - 1 \right] \right\} \quad (12)$$

For $f = 60Hz$, the result is

$$\chi_{Metglas} = \left\{ 1 - 2 \left[\sqrt{1 + 3.5 \times 10^{-22} H_{rms}^4} - 1 \right] \right\} \quad (13)$$

$$\chi_{Supermalloy} = \left\{ 1 - 2 \left[\sqrt{1 + 6.0 \times 10^{-22} H_{rms}^4} - 1 \right] \right\} \quad (14)$$

$$\chi_{Iron} = \left\{ 1 - 2 \left[\sqrt{1 + 4.1 \times 10^{-23} H_{rms}^4} - 1 \right] \right\} \quad (15)$$

Then, for $H_{rms} = 4 \times 10^5 A/m$ ($B = 0.5T$), we get

$$\chi_{Metglas} = -3.3 \Rightarrow m_{g(Metglas)} = -3.3 m_{i0(Metglas)}$$

$$(P_{Metglas}) = m_{g(Metglas)} g = -3.3 m_{i0(Metglas)} g = \underline{-3.3P}$$

$$\chi_{Smalloy} = -5.1 \Rightarrow m_{g(Smalloy)} = -5.1 m_{i0(Smalloy)}$$

$$(P_{Smalloy}) = m_{g(Smalloy)} g = -5.1 m_{i0(Smalloy)} g$$

$$\chi_{Iron} = -0.13 \Rightarrow m_{g(Iron)} = -0.13 m_{i0(Iron)}$$

$$(P_{Iron}) = m_{g(Iron)} g = -0.13 m_{i0(Iron)} g$$

The results above can be easily checked by means of the experimental set-up shown in Fig.1.

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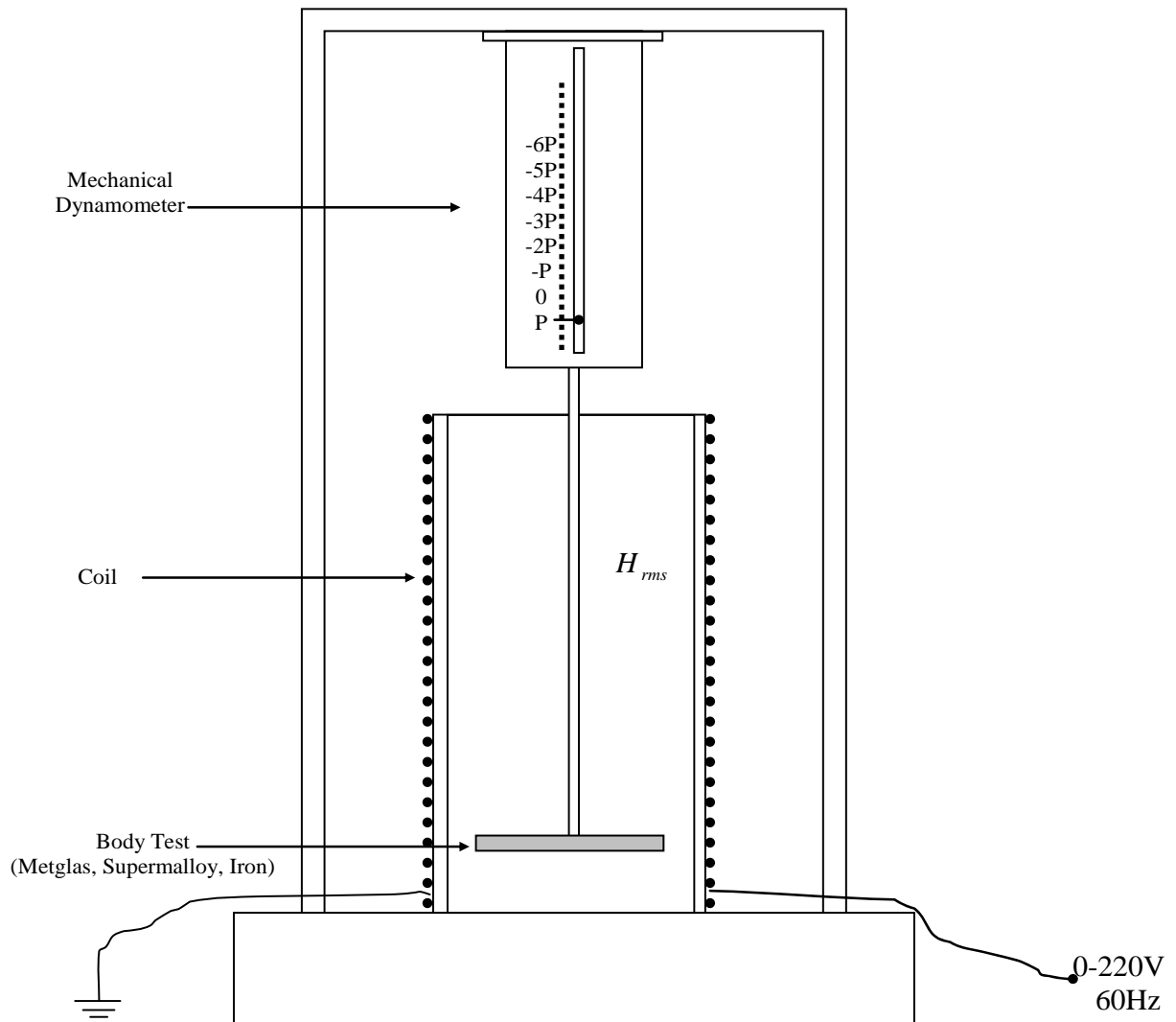


Fig. 1 – Schematic diagram of the experimental set-up to check the decreasing of the *Gravitational Mass* in materials with *Extremely High Permeability* subjected to an Alternating Magnetic Field with frequency $f = 60\text{Hz}$.

APPENDIX: How the Inertial Properties of a Spacecraft can be strongly reduced.

Consider the schematic diagram of a spacecraft shown in Fig. 2. At the center of the spacecraft has a ferromagnetic material with *Extremely High Permeability*, μ , subjected to an alternating magnetic field H_{rms} of *Extra-low frequency*, f . According to Eq.(9), its *gravitational mass*, m_{gC} , is then given by

$$m_{gC} = \left\{ 1 - 2 \left[\sqrt{1 + \left(\frac{\mu^3 \sigma}{4\pi f \rho^2 c^2} \right) H_{rms}^4} - 1 \right] \right\} m_{i0C} \quad (A1)$$

In the equation (A1), σ is the electrical conductivity of the ferromagnetic material; ρ is its mass density, and m_{i0C} is the *rest inertial mass* of the mentioned material.

Ferromagnetic core with *Extremely High Permeability*, μ , subjected to an alternating magnetic field, H_{rms} , of *Extra-low frequency*, f .

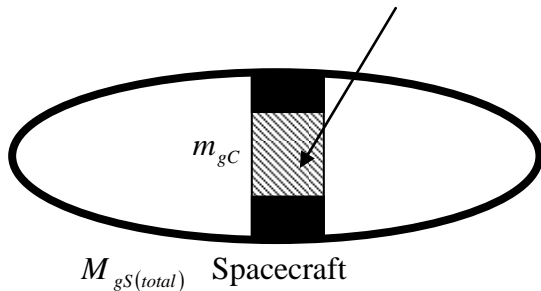


Fig.2 – Schematic diagram of an Ellipsoidal Spacecraft

Then, the *total* gravitational mass of the spacecraft, $M_{gS(total)}$, can be expressed by means of the following expression:

$$M_{gS(total)} = M_{gS} + m_{gC} \quad (A2)$$

where M_{gS} is the total gravitational mass of the spacecraft *without* the gravitational mass of the ferromagnetic core. Assuming that density of *external* electromagnetic energy in M_{gS} is negligible, then we can write that $M_{gS} \cong M_{i0S}$, where M_{i0S} is the *rest inertial mass* of the spacecraft (without the ferromagnetic core) (See Eq. 1). Thus, Eq. (A2) can be rewritten as follows:

$$\begin{aligned} M_{gS(total)} &\cong M_{i0S} + m_{gC} = \\ &\cong M_{i0S} + \left\{ 1 - 2 \left[\sqrt{1 + \left(\frac{\mu^3 \sigma}{4\pi f \rho^2 c^2} \right) H_{rms}^4} - 1 \right] \right\} m_{i0C} \quad (A3) \end{aligned}$$

Therefore, for $(\mu^3 \sigma / 4\pi f \rho^2 c^2) H_{rms}^4 \gg 1$, we get

$$M_{gS(total)} \cong M_{i0S} - \left[\sqrt{\left(\frac{\mu^3 \sigma}{\pi f \rho^2 c^2} \right) H_{rms}^4} \right] m_{i0C} \quad (A4)$$

If the ferromagnetic material is the *Supermalloy*, then Eq. (A4) gives (See Eq. (11))

$$M_{gS(total)} \cong M_{i0S} - \left[\sqrt{3.6 \times 10^{-20} \left(\frac{H_{rms}^4}{f} \right)} \right] m_{i0C} \quad (A5)$$

For example, if $M_{gS} \cong M_{i0S} = 10,000 \text{ kg}$; $m_{i0C} = 100 \text{ kg}$; $f = 1 \text{ Hz}$ and $H_{rms} = 7.2597 \times 10^5 \text{ A/m}$, ($B_{rms} \cong 0.9 \text{ T}$), then Eq. (A5) yields

$$M_{gS(total)} < 1 \text{ kg}.$$

This means a decreasing greater than 10,000 times in the gravitational mass of the spacecraft.

Mach's principle predicts that *inertial forces* acting on a particle are the result from the *gravitational* interaction between the particle and the other particles of the Universe. Thus, the inertial forces F_{ii} acting on a particle are proportional to *gravitational mass*, m_g , of the particle, i.e., $F_{ii} = m_g a_i$ [1].

This fact shows that the inertial effects upon a spacecraft can be strongly reduced because, as we have seen, the *gravitational mass* of the spacecraft $M_{gS(total)}$ can be strongly reduced ($F_{ii} = M_{gS(total)} a_i$). In practice, it means that will be possible to become *quasi-null* the inertial properties of the spacecraft.

Under these circumstances, the spacecraft can describe incredible trajectories, and to make super accelerations and super decelerations in a very short time interval ($< 1 \text{ s}$), without be destructed (See *The Gravitational Spacecraft* [5]).