Decreasing of *Gravitational Mass* of the First Room-Temperature Ambient-Pressure Superconductor LK-99, when it is subjected to an Alternating Magnetic Field of *Extremely Low Frequency*.

Fran De Aquino
Professor Emeritus of Physics, Maranhao State University, UEMA.
Titular Researcher (R) of National Institute for Space Research, INPE

http://users.elo.psi.br/~deaquino/
deaquino@elointernet.com.br

Here we propose an experiment to check the decreasing of *Gravitational Mass* of the First Room-Temperature Ambient-Pressure Superconductor LK-99, when it is subjected to an alternating magnetic field of *extremely low frequency*.

Key words: Gravitational Mass, Magnetic Field of Extremely Low Frequency, Superconductor LK-99.

INTRODUCTION

In a previous paper [1], we have proposed an experiment to check the decreasing of *Gravitational Mass* of the light metal *Magnesium* subjected to an alternating magnetic field of Extremely Low Frequency.

Here, we propose a similar experiment to check the decreasing of *Gravitational Mass* of the First Room-Temperature Ambient-Pressure Superconductor LK-99, when it is subjected to an alternating magnetic field of *extremely low frequency*.

THEORY

We have show that there is a correlation between the gravitational mass, m_g, and the rest inertial mass m_{i0}, which is given by [2]

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

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

$$W = \tfrac{1}{2}\varepsilon E^2 + \tfrac{1}{2}\mu H^2 \tag{2}$$

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 $B = \mu H$, $E/B = \omega/k_r$ [3] and

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

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 ($\varepsilon = \varepsilon_r \varepsilon_0$; $\varepsilon_0 = 8.854\times10^{-12} F/m$; $\mu = \mu_r \mu_0$ where $\mu_0 = 4\pi\times10^{-7} H/m$; 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

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

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

$$E = vB = v\mu H \tag{5}$$

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

$$W = \tfrac{1}{2}\varepsilon\, v^2 \mu^2 H^2 + \tfrac{1}{2}\mu H^2 =$$
$$= \tfrac{1}{2}\mu H^2 \left(\varepsilon v^2 \mu\right) + \tfrac{1}{2}\mu H^2 = \mu H^2 \qquad (6)$$

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

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

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

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

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 sinusoidaly (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

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

NEW SUGGESTED EXPERIMENT

Consider the schematic diagram of the system shown in Fig.1.

The magnetic field, B_{rms}, produced by the superconductor inductor (LK-99) *creates an induced magnetic field* in the LK-99 cylinder in the *opposite direction*, causing a *repulsive* magnetic force between both the magnetic fields. The magnetic field induced in the LK-99 cylinder produces a decreasing of its *Gravitational Mass*, which, according to Eq. (9), becomes $m_{g(LK-99)} = \chi m_{i0(LK-99)}$, where χ is given by

$$\chi = \frac{m_{g(LK-99)}}{m_{i0(LK-99)}} = \left\{1 - 2\left[\sqrt{1 + \left(\frac{\sigma}{4\pi\ f \mu \rho^2 c^2}\right)B_{rms}^4} - 1\right]\right\} \qquad (10)$$

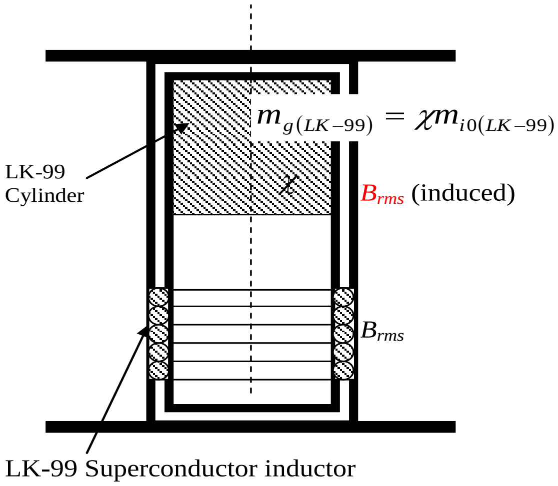

Fig. 1 - The magnetic field, B_{rms}, produced by the superconductor inductor (LK-99) *induces a magnetic field* in the LK-99 Cylinder. According to Eq. (9), this magnetic field produces a decreasing of the *Gravitational Mass* of the LK-99 Cylinder.

According to [4] the LK-99 has resistivity in the order of $10^{-10} \sim 10^{-11}\Omega.cm$, which points to a *conductivity* $\sigma \sim 10^{12}\, S/m$. This means that the LK-99 is a superconductor of *low electrical conductivity*, because according to the studies by File and Mills [5], the decay time in a superconducting solenoid is on the order of 100,000 years, and the upper limit of resistivity of the material would be on the order of $10^{-25}\Omega.m$, which points to a *conductivity* $\sigma \sim 10^{25}\, S/m$ *. The conductivity measurements have shown similar results to the well-known results obtained for the first time by H.K.Onnes [6]. The low-temperature conductivity exhibited by the Hg samples was $\sigma \sim 10^{22}\, S/m$ for different current densities.

The *known* superconductors have *magnetic susceptibility* equal to -1, i.e., $\chi_V = -1$. Consequently, they have *null magnetic permeability*: $\mu = \mu_r \mu_0 = (\chi_V + 1)\mu_0 = 0$. Eq. (8) shows that if $\mu = 0$, it reduces to

$$\chi = \frac{m_g}{m_{i0}} = 1$$

---

* Note that, the resistivity of the superconductors *is not null*, just too small.

This may lead us to think that the gravitational mass of these superconductors cannot be reduced by the action of electromagnetic fields. But, this is not true, because as we have shown in a previous paper [7], the gravitational masses of the *electrons* inside a superconductor are reduced by the action of electromagnetic fields, reducing in this way the *total* gravitational mass of the superconductor.

According to [4] the *volumetric magnetic susceptibility* of the LK-99 is *much greater than* the volumetric magnetic susceptibility of the (single crystal) *graphite*, which is -8.3×10^{-4}. But, it does not equal to -1, like the volumetric magnetic susceptibility of the *known* superconductors. Consequently, for LK-99 we can assume that $\mu = \mu_r\mu_0 = (\chi_V + 1)\mu_0 \cong \mu_0$. Thus, we can apply Eq. (10) in order to calculate the correlation $\chi = m_{g(LK-99)} / m_{i0(LK-99)}$.

The mass density of the LK-99 is given by $\rho \cong 6699 kg/m^3$ [8]. Substitution of theses values ($\sigma \sim 10^{12} S/m$ and $\rho \cong 6699 kg/m^3$) into Eq. (10) gives

$$\chi = \frac{m_{g(LK-99)}}{m_{i0(LK-99)}} = \left\{1 - 2\left[\sqrt{1 + \frac{\sim 10^{-8} B_{rms}^4}{f}} - 1\right]\right\} \qquad (11)$$

For $f \cong 1\mu Hz \cong 10^{-6} Hz$ † Eq. (11) gives

$$\chi = \frac{m_{g(LK-99)}}{m_{i0(LK-99)}} = \left\{1 - 2\left[\sqrt{1 + 10^{-2} B_{rms}^4} - 1\right]\right\} \qquad (12)$$

For $B_{rms} = 5.6\ T$ ‡ Eq. (12) gives

$$\chi = -3.6 \qquad (13)$$

Thus, the *weight* P of the LK-99 cylinder becomes

$$P_{(LK-99)} = m_{g(LK-99)} g = \chi\ m_{i0(LK-99)} g = -3.6 m_{i0(LK-99)} g \qquad (14)$$

For example, if $m_{i0(LK-99)} = 6699 kg$ ($1m^3$ of LK-99), the result is

$$P_{(LK-99)} = -3.6 m_{i0(LK-99)} g = = -24116.4 g = -236{,}34 kN \qquad (15)$$

The system shown in Fig. 1 has many possibilities for various applications. In Fig.2 we show one of them (rockets).

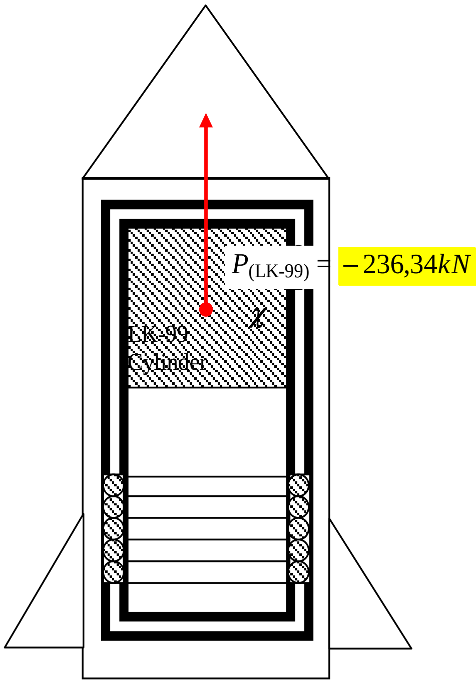

Fig. 2 – Assuming that the rocket inertial mass (without the LK-99 cylinder) is $m_{i0(rocket)} = 15\ ton$, then the acceleration of the rocket will be given by $a_{rocket} = P_{(LK-99)} / m_{i0(rocket)} = 15.7 m.s^{-2}$.

Another application is in the *gravity control*. In a previous paper [2], we have show that if the gravity below a plate is g then, the gravity above the plate is $g' = \chi g$, where χ is given by $\chi = m_{g(plate)} / m_{i0(plate)}$.

CONCLUSION

These results show that the discovery of the First Room-Temperature Ambient-Pressure Superconductor LK-99 can be highly relevant because we can check the possibility of decreasing of *Gravitational Mass* using an alternating magnetic field of *extremely low frequency*.

---

† The recent appearing of the Function Generators capable of generating sine waves with frequency of down to $0.01\mu Hz = 10^{-8} Hz$ [9], became possible to reduce the value of B for values less than 1.8 T (range of magnetic fields intensities of the *conventional* magnetic inductors).

‡ Modern *magnetic resonance imaging systems* work with magnetic fields up to $8T$ [10, 11].

References

[1] De Aquino, F. (2021) *Deceasing of Gravitational Mass of the Magnesium subjected to an Alternating Magnetic Field of Extremely Low Frequency*. Available at: https://hal.science/hal-03120208

[2] De Aquino, F. (2010) *Mathematical Foundations of the Relativistic Theory of Quantum Gravity*, Pacific Journal of Science and Technology,**11** (1), pp. 173-232. Available at: https://hal.archives-ouvertes.fr/hal- 01128520

[3] Halliday, D. and Resnick, R. (1968) *Physics*, J. Wiley & Sons, Portuguese Version, Ed. USP, p.1118.

[4] Sukbae Lee1, Ji-Hoon Kim, Young-Wan Kwon (2023) .*The First Room-Temperature Ambient-Pressure Superconductor.* https://arxiv.org/abs/2307.12008

[5] File, J. and Mills, R.G. (1963). *Observation of persistent current in a superconducting solenoid*. Physical Review Letters, 10(3):93.

[6] Onnes, H.K. (1911) *Commun. Phys. Lab*., **12**,120.

[7] De Aquino, F.,(2002).*Gravitational Mass at the Superconducting State*, arXiv physics/0201058; De Aquino, F., (2003). *Effects of Extreme-Low Frequency Electromagnetic Fields on the Weight of the Hg at the Superconducting State*.

[8] https://en.wikipedia.org/wiki/LK-99; 2514.2AMU /(sin(60°)*9.843*9.843*7.428 Å^3)

[9] The FG400 easily generates basic, application specific and arbitrary waveforms with a sine wave frequency range of 0.01μHz to 30 MHz. See: https://tmi.yokogawa.com/solutions/products/generators-sources/function-generators/fg400-series-arbitraryfunction-generator/

[10] Smith, Hans-Jørgen. "Magnetic resonance imaging". *Medcyclopaedia Textbook of Radiology*. GE Healthcare. Retrieved 2007-03- 26.

[11] Orenstein, Beth W. (2006-02-16). "Ultra High- Field MRI — The Pull of Big Magnets". *Radiology Today* **7** (3): pp. 10. Archived from the original on March 15, 2008. Retrieved 2008-07-10