Bose-Einstein Condensate and Gravitational Shielding

Fran De Aquino

In this work we show that when possible transform some types of substance into a Bose-Einstein condensate at room temperature, which exists long enough to be used in practice then will be possible to use these substances in order to create efficient Gravitational Shieldings.

Key words: Quantum Gravity, Gravitation, Gravitational Shielding, Bose-Einstein Condensate.

The quantization of gravity shows that the *gravitational mass* m_g and *inertial mass* m_i are correlated by means of the following factor [1]:

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

where m_{i0} is the *rest* inertial mass of the particle and Δp is the variation in the particle's *kinetic momentum*; c is the speed of light.

In general, the *momentum* variation Δp is expressed by $\Delta p = F\Delta t$ where F is the applied force during a time interval Δt. Note that there is no restriction concerning the *nature* of the force F, i.e., it can be mechanical, electromagnetic, etc.

For example, we can look on the *momentum* variation Δp as due to absorption or emission of *electromagnetic energy*. In this case, we can write that

$$\Delta p = n\hbar k_r = n\hbar\omega/(\omega/k_r) = \Delta E/(dz/dt) =$$
$$= \Delta E/v = \Delta E/v(c/c) = \Delta E n_r/c \qquad (2)$$

where k_r is the real part of the *propagation vector* $\vec{k}$; $k = |\vec{k}| = k_r + ik_i$; ΔE is *the electromagnetic energy absorbed or emitted by the particle;* n_r is the index of refraction of the medium and v is the *phase* velocity of the electromagnetic waves, given by:

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

ε, μ and σ, are the electromagnetic characteristics of the particle ($\varepsilon = \varepsilon_r\varepsilon_0$ where ε_r is the *relative electric permittivity* and $\varepsilon_0 = 8.854 \times 10^{-12} F/m$; $\mu = \mu_r\mu_0$ where μ_r is the *relative magnetic permeability* and $\mu_0 = 4\pi \times 10^{-7} H/m$).

Thus, substitution of Eq. (2) into Eq. (1), gives

$$\chi = \frac{m_g}{m_{i0}} = \left\{1 - 2\left[\sqrt{1 + \left(\frac{\Delta E}{m_{i0}c^2} n_r\right)^2} - 1\right]\right\} \qquad (4)$$

By dividing ΔE and m_{i0} in Eq. (4) by the volume V of the particle, and remembering that, $\Delta E/V = W$, we obtain

$$\chi = \frac{m_g}{m_{i0}} = \left\{1 - 2\left[\sqrt{1 + \left(\frac{W}{\rho\, c^2} n_r\right)^2} - 1\right]\right\} \qquad (5)$$

where ρ is the matter density $\left(kg/m^3\right)$.

Equation (2) tells us that $F = d(\Delta p)/dt = (1/v)d(\Delta E)/dt$. Since $W \equiv$ *pressure* Then we can write that $W = F/A = (1/v)d(\Delta E)/dt\,A = D/v$, where D is the power density of the absorbed (or emitted) radiation. Substitution of $W = D/v$ into Eq. (5) yields

$$\chi = \frac{m_g}{m_{i0}} = \left\{1 - 2\left[\sqrt{1 + \left(\frac{D}{\rho\, c^3} n_r^2\right)^2} - 1\right]\right\} =$$
$$= \left\{1 - 2\left[\sqrt{1 + \left(\frac{D}{\rho\, cv^2}\right)^2} - 1\right]\right\} \qquad (6)$$

In a previous paper [2] it was shown that, if the *weight* of a particle in a side of a lamina is $P = m_g g$ then the weight of the same particle, in the other side of the lamina is $P' = \chi m_g g$, where $\chi = m_g/m_{i0}$ (m_g and m_{i0} are respectively, the gravitational mass and the inertial mass of the lamina). Only when $\chi = 1$, the weight is equal in both sides of the lamina. The lamina works as a Gravitational Shielding. This is the *Gravitational Shielding* effect. Since $P' = \chi P = (\chi m_g)g = m_g(\chi g)$, we can consider that $m'_g = \chi m_g$ or that $g' = \chi g$.

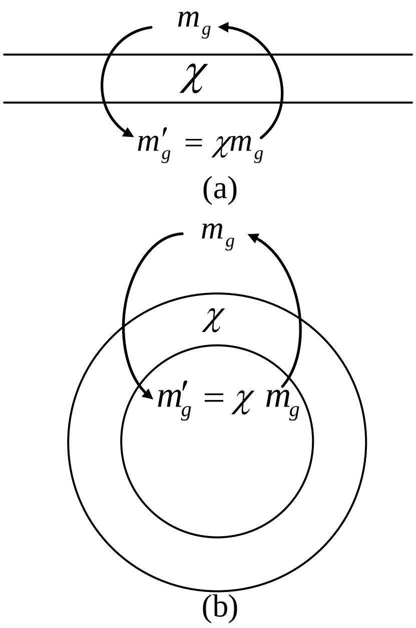

Fig. 1 – *Plane* and *Spherical* Gravitational Shieldings. When the radius of the gravitational shielding (b) is very small, any particle inside the spherical crust will have its gravitational mass given by $m'_g = \chi\, m_g$, where m_g is its gravitational mass out of the crust.

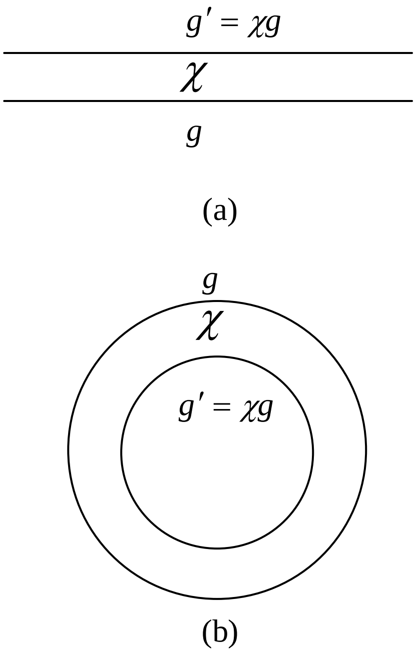

Fig. 2 – The gravity acceleration in both sides of the gravitational shielding.

In 1999, Danish physicist Lene Hau et al., by passing a light beam through a Bose-Einstein condensate (BEC) of sodium atoms at *nK*, succeeded in slowing a beam of light to about 17 meters per second [3]. In this case, the enormous index of refraction $(n_r = c/v)$ of the BEC is equal to 17.6 million. Even higher refractive indices are expected (light speed as low as *micrometer/sec*).

According to Eq. (6), this strong decreasing of v, shows that the values of χ in a BEC can be strongly reduced with small values of D. This can be very useful to create Gravitational Shieldings.

The Hau's experiment requires temperatures near absolute zero. However, at the beginning of 2013, Ayan Das and colleagues [4] have used *nanowires* to produce an excitation known as a *polariton*[1]. These polaritons formed a Bose-Einstein condensate *at room temperature*, potentially opening up a new way for studying systems that otherwise require expensive cooling and trapping. Instead of atoms, condensation was achieved using *quasiparticles*.

At the end of 2013 researchers at IBM's Binning and Rohrer Nano Center have been able to achieve the BEC at room temperature by placing a thin polymer film[2]—only 35 nanometers thick—between two mirrors and then shining a laser into the configuration [5]. The photons of the laser interact with *excitions*[3] [6] leading to the onset of a new *quasi-particle* that exhibits properties of light and matter - *Polaritons*. Because polaritonic quasiparticles have extraordinarily light masses and *they are bosons*, they can condense together in a single quantum state. This makes for extremely unusual emitters, as well as new solid-state devices *exhibiting Bose-Einstein condensation at room temperature*. Unfortunately, this BEC state of matter only lasts for a few picoseconds.

When possible transform some types of substance into a Bose-Einstein condensate at room temperature, which exists long enough to be used in practice then will be possible to use these substances in order to create efficient *Gravitational Shieldings*, according to (6).

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[1] *Polaritons* are quasiparticles resulting from strong coupling of electromagnetic waves with an electric or magnetic dipole-carrying excitation.

[2] The luminescent plastic film is similar to that used in many smart phones for their light-emitting displays.

[3] An *exciton* is a bound state of an electron and an electron hole which are attracted to each other by the electrostatic Coulomb force. It is an electrically neutral quasiparticle that exists in insulators, semiconductors and in some liquids. The exciton is regarded as an elementary excitation of condensed matter that can transport energy without transporting net electric charge [6].

References

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