A Possible Explanation for Anomalous Heat Production in Ni-H Systems

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Anomalous heat production has been detected in Ni-H Systems. Several evidences point to the occurrence of nuclear fusion reactions. A possible explanation for this phenomenon is shown here based on the recent discovery that electromagnetic fields of extremely-low frequencies (ELF) can increase the intensities of gravitational forces. Under certain circumstances, the intensities of gravitational forces can even overcome the intensity of the electrostatic repulsion forces, and, in this way, produce nuclear fusion reactions, without need high temperatures for these reactions occur.

Key words: Modified theories of gravity, Nuclear Fusion**,** Fusion Reactors.
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1. Introduction

Since the experiment of Fleischmann, Hawkins and Pons [1] the anomalous production of heat has been searched for in various systems. Recently, a large anomalous production of heat has been reported by Focardi et al., [2] in a nickel rod filled with hydrogen. This phenomenon was posteriorly confirmed by Cerron-Zeballos et al., [3].

The called "cold fusion" was a process of nuclear fusion that was first conceived of by Fleischmann, Hawkins and Pons during their experiment that involved heavy water electrolysis through hydrogen on a palladium electrode surface [1]. They made claims originally that there was heat and energy being created from the reaction taking place at room temperature. This is why it is referred to as cold fusion, because it occurred in an environment that was previously considered too cool for *nuclear fusion to occur*.

Here it is shown that nuclear fusion can be produced at room temperature by *increasing the gravitational forces in order to overcome the electrostatic repulsion forces between the nucle*i. This process became feasible after the Quantization of Gravity [4], with the discovery that the *gravitational mass* m_g can be made negative and strongly intensified by means of electromagnetic fields of extremely-low frequencies.

This effect can provide a consistent and coherent explanation for anomalous heat production detected in Ni-H Systems.

2. Theory

The quantization of gravity shown that the *gravitational mass* m_g and *inertial mass* m_i are correlated by means of the following factor [4]:

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

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.

When Δp is produced by the absorption of a photon with wavelength λ, it is expressed by $\Delta p = h/\lambda$. In this case, Eq. (1) becomes

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

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

where $\lambda_0 = h/m_{i0}c$ is the *De Broglie wavelength* for the particle with *rest* inertial mass m_{i0}.

From Electrodynamics we know that when an electromagnetic wave with frequency f and velocity c incides on a material with relative permittivity ε_r, relative magnetic permeability μ_r and electrical conductivity σ, its *velocity is* *reduced* to $v = c/n_r$ where n_r is the index of refraction of the material, given by [5]

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

If $\sigma >> \omega\varepsilon$, $\omega = 2\pi f$, 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 (See Fig . 1) becomes

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

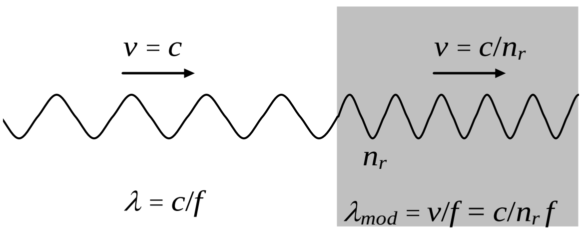

Fig. 1 – *Modified Electromagnetic Wave*. The wavelength of the electromagnetic wave can be strongly reduced, but its frequency remains the same.

It is known that the *Schumann resonances* [6] are global electromagnetic resonances (a set of spectrum peaks in the extremely low frequency ELF), excited by lightning discharges in the *spherical resonant cavity* formed by the Earth's surface and the inner edge of the ionosphere (60km from the Earth's surface). The Earth–ionosphere waveguide behaves like a resonator at ELF frequencies and amplifies the spectral signals from lightning at the resonance frequencies. In the normal mode descriptions of Schumann resonances, the fundamental mode $(n=1)$ is a standing wave in the Earth–ionosphere cavity with a wavelength equal to the circumference of the Earth. This lowest-frequency (and highest-intensity) mode of the Schumann resonance occurs at a frequency $f_1 = 7.83Hz$ [7].

Now consider a $7.83Hz$ $(\lambda \cong 3.8\times10^7 m)$ radiation passing through a *Nickel powder* cylinder ($\sigma = 1.6\times10^7 S/m$; $\mu_r = 2.17$ [8,9]) as shown in Fig.2. According to Eq. (5), the *modified wavelength* is

$$\lambda_{\text{mod}} = \sqrt{\frac{4\pi}{\mu f \sigma}} = 0.19m \qquad (6)$$

Consequently, the wavelength of the $7.83Hz$ radiation *inside the Nickel powder* will be $\lambda_{\text{mod}} = 0.19m$ and not $\lambda \cong 3.8\times10^7 m$.

If a *Nickel powder** lamina with thickness equal to ξ contains n molecules/m^3, then the number of molecules per area unit is $n\xi$. Thus, if the electromagnetic radiation with frequency f incides on an area S of the lamina it reaches $nS\xi$ molecules. If it incides on the total area of the lamina, S_f, then the total number of molecules reached by the radiation is $N = nS_f\xi$. The number of molecules per unit of volume, n, is given by

$$n = \frac{N_0 \rho}{A} \qquad (7)$$

where $N_0 = 6.02\times10^{26} molecules/kmole$ is the Avogadro's number; ρ is the matter density of the lamina (in *kg/m*^{3}) and A is the molar mass. In the case of *Nickel powder* $\left(\rho = 8800 kg/m^3, A = 58.71 kg.kmole^{-1}\right)$ the result is

$$n_{(Ni)} = 9.02\times10^{28} molecules/m^3 \qquad (8)$$

The *total number of photons* inciding on the Nickel powder is $n_{total\ photons} = P/hf^2$, where P is the power of the radiation flux incident on the Nickel powder.

* Ultra fine nickel powder (e.g. Inco type 210) with particle size of 0.5-1.0μm.

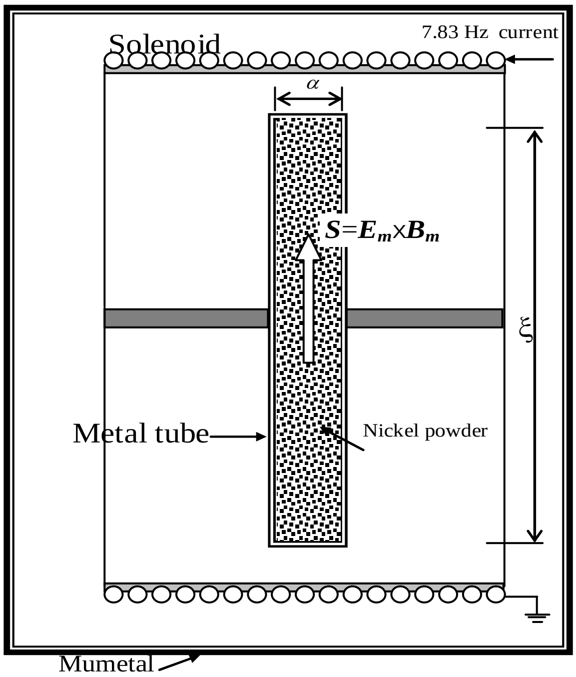

Fig.2 – *Experimental set-up*. The electromagnetic radiation propagates in the direction of the vector of *Pointing* $\vec{S} = \vec{E} \times \vec{B}$. The set-up is placed in a container shielded by 1 mm thick layer of *mumetal* in order to avoid interference from external electromagnetic fields. In practice, the solenoid is not necessary, since the 7.83 Hz electromagnetic field naturally exists inside the *spherical resonant cavity* formed by the Earth's surface and the inner edge of the ionosphere. (Schumann resonance).

When an electromagnetic wave incides on a *solid* lamina of Nickel, it strikes on N_f front molecules, where $N_f \cong (n_{(Ni)} S_f)\phi_{(Ni)}$. Thus, the electromagnetic wave incides effectively on an area $S = N_f S_{(Ni)}$, where $S_{(Ni)} = \frac{1}{4}\pi\phi^2_{(Ni)} \cong 1.2\times10^{-20}\,m^2$ is the cross section area of one *Ni* atom. After these collisions, it carries out $n_{collisions}$ with the other atoms of the Nickel powder (See Fig.3).

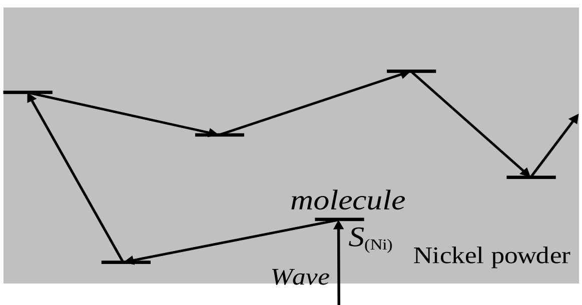

Fig. 3 – *Collisions inside the* Nickel powder.

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

$$N_{collisions} \cong N_f + n_{collisions} \cong n_{(Ni)} S\phi_{(Ni)} + \left(n_{(Ni)} S\xi - n_{(Ni)} S\phi_{(Ni)}\right) = \\ = n_{(Ni)} S\xi \qquad (9)$$

The power density, D, of the radiation on the Nickel powder can be expressed by

$$D = \frac{P}{S} = \frac{P}{N_f S_{(Ni)}} \qquad (10)$$

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

$$n_1 = \frac{n_{total\ \ photons} N_{collisions}}{N} \qquad (11)$$

Since in each collision a *momentum* h/λ is transferred to the molecule, then the *total momentum* transferred to the Nickel will be $\Delta p = (n_1 N) h/\lambda$. Therefore, in accordance with Eq. (1), we can write that

$$\frac{m_{g(w)}}{m_{i0(w)}} = \left\{1 - 2\left[\sqrt{1 + \left[(n_1 N)\frac{\lambda_0}{\lambda}\right]^2} - 1\right]\right\} = \\ = \left\{1 - 2\left[\sqrt{1 + \left[n_{total\ photons} N_{collisions}\frac{\lambda_0}{\lambda}\right]^2} - 1\right]\right\} \qquad (12)$$

Since Eq. (9) gives $N_{collisions} = n_{(Ni)} S\xi$, we get

$$n_{total\ \ photons} N_{collisions} = \left(\frac{P}{hf^2}\right)\left(n_{(Ni)} S\xi\right) \qquad (13)$$

Substitution of Eq. (13) into Eq. (12) yields

$$\frac{m_{g(Ni)}}{m_{i0(Ni)}} = \left\{1 - 2\left[\sqrt{1 + \left[\left(\frac{P}{hf^2}\right)\left(n_{(Ni)} S\xi\right)\frac{\lambda_0}{\lambda}\right]^2} - 1\right]\right\} \qquad (14)$$

Substitution of P given by Eq. (10) into Eq. (14) gives

$$\frac{m_{g(Ni)}}{m_{i0(Ni)}} = \left\{1 - 2\left[\sqrt{1 + \left[\left(\frac{N_f S_{(Ni)} D}{f^2}\right)\left(\frac{n_{(Ni)} S\xi}{m_{i0(Ni)} c}\right)\frac{1}{\lambda}\right]^2} - 1\right]\right\} \qquad (15)$$

Substitution of $N_f \cong (n_{(Ni)} S_f)\phi_{(Ni)}$ and $S = N_f S_{(Ni)}$ into Eq. (15) results

$$\frac{m_{g(Ni)}}{m_{i0(Ni)}}=\left\{1-2\left[\sqrt{1+\left[\left(\frac{n_{(Ni)}^3 S_f^2 S_{(Ni)}^2 \phi_{(Ni)}^2 \xi D}{m_{i0(Ni)} c f^2}\right)\frac{1}{\lambda}\right]^2}-1\right]\right\} \quad (16)$$

where $m_{i0(Ni)} = \rho_{(Ni)} V_{cyl} = \rho_{(Ni)}\left(\pi\alpha^2/4\right)\xi$.
Thus, Eq. (16) reduces to

$$\frac{m_{g(Ni)}}{m_{i0(Ni)}}=\left\{1-2\left[\sqrt{1+\left[\left(\frac{n_{(Ni)}^3 S_f^2 S_{(Ni)}^2 \phi_{(Ni)}^2 D}{\rho_{(Ni)}\left(\pi\alpha^2/4\right) c f^2}\right)\frac{1}{\lambda}\right]^2}-1\right]\right\} \quad (17)$$

For $\phi = 5cm$ we get $S_\alpha = \pi\alpha^2/4 = 1.9\times10^{-3}m^2$. Note that S_f is not equal to S_α because the area is not continuous, but expressed by $S_f = nS_p$, where S_p is the area of the cross-section of one Ni particle, and n is *the number of particles in the front area*, which is expressed by $n = x\left(n_p \phi_p S_\alpha\right)$, $x \ll 1$, where $n_p \phi_p S_\alpha$ is the number of particles inside area S_α; n_p is the number of Ni particles/m^3, given by $n_p = N_p / S_\alpha \xi$ where $N_p = S_\alpha \xi / V_p + V_v$; V_p is the mean volume of one Ni particle and V_V is the void volume, corresponding to that particle. This volume can be calculated considering one sphere with ϕ_p- diameter inside a cube whose edge is ϕ_p. The result is $V_V \cong 0.48\phi_p^3$. The mean size of the particles is $\phi_p = 0.75\mu m$. Thus, $V_p \cong 2.2\times10^{-19}m^3$ and $S_p \cong 4.4\times10^{-13}m^2$. Consequently, $V_p + V_V \cong 4.2\times10^{-19}m^2$. Then, we get $n_p = 2.4\times10^{18}\,particles/m^3$. Now, we can calculate the value of S_f:

$$S_f = x\left(n_p \phi_p S_\alpha\right)S_p \cong x\left(1.5\times10^{-3}\right)m^2$$

Substitution of this value jointly with $n_{(Ni)} = 9.02\times10^{28}\,molecules/m^3$; $\phi_{(Ni)} = 1.24\times10^{-10}m$; $S_\alpha = \pi\alpha^2/4 = 1.9\times10^{-3}m^2$; $S_{(Ni)} \cong 1.2\times10^{-20}m^2$; $\rho_{(Ni)} = 8800\ kg.m^{-3}$; $f = 7.83\ Hz$ (Note that, this is lowest-frequency mode of the Schumann resonance. *Therefore, in practice, is not necessary to provide the 7.83 Hz electromagnetic field*) and $\lambda = \lambda_{mod} = 0.19m$ into Eq.(17), gives

$$\frac{m_{g(Ni)}}{m_{i0(Ni)}}=\left\{1-2\left[\sqrt{1+3.9\times10^{21}x^4D^2}-1\right]\right\} \quad (18)$$

Now, considering that the Nickel powder is inside a solenoid, which produces a weak ELF electromagnetic field with E_m and B_m, then we can write that [10]

$$D = \frac{E_m^2}{2\mu_0 v_{Ni}} = \frac{v_{Ni}^2 B_m^2}{2\mu_0 v_{Ni}} = \frac{cB_m^2}{2\mu_0 n_{r(Ni)}} \quad (19)$$

Equation (4) shows that, for $f = 7.83Hz$, $n_{r(Ni)} = 2\times10^8$.Substitution of this value into Eq.(19) gives

$$D = 5.9\times10^5 B_m^2 \quad (21)$$

Substitution of this value into Eq. (18) gives

$$\chi = \frac{m_{g(Ni)}}{m_{i0(Ni)}} \cong \left\{1-2\left[\sqrt{1+1.3\times10^{33}x^4B_m^4}-1\right]\right\} \quad (22)$$

The value of B_m is limited by the *ionization energy* of the atoms, which is, as we known, the energy required to remove electrons from atoms. Since the minimum energy required for the electron to leave the atom is: $U_{min} = -e^2/4\pi\varepsilon_0\phi_{max} = 7.7\times10^{-19}\,joules$ then, for the ionization does not occur, the energy of the wave (hf) must be smaller than U_{min}. Thus, it follows that

$$hf^2/S_a < U_{min}f/S_a \Rightarrow D < U_{min}f/S_a \cong f$$

According to Eq. (19), $D_{max} = cB_{max}^2/2\mu_0$. Then, the result is

$$B_{max} < 9\times10^{-8}\sqrt{f}$$

In the case of $f = 7.83Hz$, we conclude that

$$B_{max} < 2\times10^{-7}T \quad (23)$$

Assuming that $B_{max} \cong 2\times10^{-7}T$ then Eq. (22) yields

$$\chi = \frac{m_{g(Ni)}}{m_{i0(Ni)}} \cong \left\{1-2\left[\sqrt{1+2.1\times10^6x^4}-1\right]\right\} \quad (24)$$

Since $x \ll 1$, we can conclude that *there is no significant variation in the gravitational mass of the Nickel powder.*

However, if the air inside the Nickel powder is evacuated by means of a vacuum pump, and after Hydrogen (or Deuterium, Tritium, Helium, etc) is injected into the Nickel powder (See Fig.4) then, the area S_f to be considered, in order to calculate the gravitational mass of the Hydrogen, is the *surface area* of the Nickel powder, which can be obtained by multiplying the *specific surface area of the Nickel powder*† ($\sim 4\times10^3 m^2/Kg$) *by the total mass of the Nickel powder* ($m_{i0(Ni)} = \rho_{(Ni)}\left(\pi\alpha^2/4\right)\xi$). Thus, we get $S_f \cong 4\times10^3 \rho_{(Ni)} S_\alpha \xi$.

The characteristics of the Nickel prevail on those of the Hydrogen, in the Ni-H systems, because the Nickel amount is much larger than the Hydrogen amount. Thus, we must take the values of ρ, μ_r, and σ equal to $\rho_{(Ni)}$, $\mu_{r(Ni)}$ and $\sigma_{(Ni)}$ respectively, in order to calculate $m_{g(H)}$, in Ni-H systems. In addition, since $n = N_0\rho/A$ and $\lambda_{\text{mod}} = \sqrt{4\pi/\mu f\sigma}$ we can conclude that also $n \equiv n_{(Ni)}$ and $\lambda_{\text{mod}} = \lambda_{\text{mod}(Ni)} = 0.19m$. Therefore, in order to obtain the expression $m_{g(H)}/m_{i0(H)}$ we can take Eq. (17) only substituting S_f for the expression above obtained $\left(S_f \cong 4\times10^3 \rho_{(Ni)} S_\alpha \xi\right)$. Thus we get

$$\frac{m_{g(H)}}{m_{i0(H)}} = \left\{1-2\left[\sqrt{1+\left[\left(\frac{n^3_{(Ni)}\rho_{(Ni)}S_\alpha\xi^2S^2_{(Ni)}\phi^2_{(Ni)}D}{18.7f^2}\right)\frac{1}{\lambda}\right]^2}-1\right]\right\} \quad (25)$$

For $\xi = 0.1m$ (length of the Ni-H cylinder in Focardi experiment) Eq.(25) gives

$$\chi = \frac{m_{g(H)}}{m_{i0(H)}} = \left\{1-2\left[\sqrt{1+1.5\times10^{48}D^2}-1\right]\right\} \quad (26)$$

Based on Eq. (19), we can write that $D = cB_m^2/2\mu_0\, n_{r(H)}$, where $n_{r(H)} \cong 1$. Thus, we get $D = 1.2\times10^{14}B_m^2$. Substitution of this expression into Eq. (26) yields

$$\chi = \frac{m_{g(H)}}{m_{i0(H)}} = \left\{1-2\left[\sqrt{1+2.1\times10^{76}B_m^4}-1\right]\right\} \quad (27)$$

It is known that, at any time in the *spherical resonant cavity* formed by the Earth's surface and the inner edge of the ionosphere (60km from the Earth's surface) there is a drop voltage of 200KV. This, produces an electric field with intensity $E_m \cong 3V/m$, which gives $B_m \cong 1\times10^{-8}T$. Substitution of this value into Eq. (27), yields

$$\chi \cong -2\times10^{22} \quad (28)$$

Thus, the gravitational forces between two protons (hydrogen nuclei) becomes

$$F = -Gm_{gp}^2/r^2 = -\chi^2 Gm_{ip}^2/r^2 \cong -7\times10^{-20}/r^2$$

Comparing with the electrostatic repulsion forces between the nuclei, which is given by

$$F_e = e^2/4\pi\varepsilon_0 r^2 = 2.3\times10^{-28}/r^2$$

We conclude that the intensities of the gravitational forces *overcome the intensities of the electrostatic repulsion forces between the nucle*i. This is sufficient to produce their fusion.

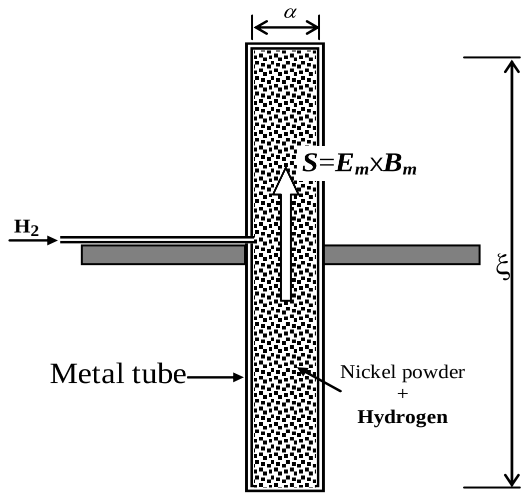

Fig.4 – *Cold Fusion Reactor on Earth*. Note that here the 7.83 Hz electromagnetic field is what naturally exists inside the *spherical resonant cavity* formed by the Earth's surface and the inner edge of the ionosphere. (Schumann resonance).

† Ultra fine nickel powder (e.g. Inco type 210) with particle size of 0.5-1.0μm has specific surface areas range from 1.5 to 6m^2/g [11]. Hydrogen production with *nickel powder cathode* points to a value of 4.31m^2 /g in the case of new cathodes, and 3.84 m^2 /g in the case of used cathodes [12].

The enormous value of χ (Eq. 28) strongly increases the gravitational masses of the Hydrogen nuclei ($m_{gp} = \chi m_{i0p}$) and their respective electrons ($m_{ge} = \chi m_{i0e}$). Thus, the gravitational force between a nucleus (proton) and the corresponding electron is given by $F_{pe} = -\chi^2 G m_{i0p} m_{i0e} / r^2$ and the gravitational force between two Hydrogen nuclei is $F_{pp} = -\chi^2 G m_{i0p} m_{i0p} / r^2$. Therefore, two well-known types of fusions can occur, i.e.,

$$p + e^- \rightarrow n + \nu_e \qquad (29)$$

$$p + p \rightarrow d + \nu_e + e^+ + 0.42MeV \qquad (30)$$

Due to the strong gravitational attraction, the following fusions occur instantaneously:

$$d + \nu_e \rightarrow n + p + \nu_e$$

and

$$n + e^+ \rightarrow p + \bar{\nu}_e$$

These reactions are widely known because they have been studied extensively due to their importance in astrophysics and neutrino physics [13–16]. Thus, the term $p + \nu_e + e^+$ in Eq. (30) reduces instantaneously to $p + p + \nu_e + \bar{\nu}_e$.

In these fusion reactions, *neutrons* (Eq. (29)), *neutrinos* and *antineutrinos*, and *energy* (0.42MeV at each fusion of two Hydrogen nuclei) are produced. Note that *there is no gamma ray emission* during the process. The evidence of neutron emission during energy production in Ni-H systems has been reported by Battaglia, A. et al., [17].

In order to calculate the number of Hydrogen atoms/m^3 inside the Nickel powder we will calculate the density of the Hydrogen. According to *Focardi's* experiments, the pressure of the Hydrogen is $P = 0.051 atm = 5.166 \times 10^3 N/m^2$ at temperature $T = 400K$. Thus, according to the well-kwon *Equation of State* $\rho = PM_0 / ZRT$, we get

$$\rho_H = \frac{\left(5.166 \times 10^3 N/m^2\right)\left(2 \times 10^{-3} kg.mol^{-1}\right)}{(\sim 1)\left(8.314\, joule.mol^{-1}.K^{-1}\right)(400K)} =$$
$$= 3.1 \times 10^{-3} kg/m^3$$

Thus, the number of Hydrogen atoms/m^3 inside the Nickel powder is

$$n_H = N_0 \rho_H / A_{H2} = 3.01 \times 10^{26} \rho_H \quad atoms/m^3$$

Then, the number of H atoms inside the Nickel powder is given by

$$n_H V_H = n_H S_f \delta_H \cong 8.3 \times 10^{24} \rho_H \alpha^2 \xi$$

where $\delta_H = \Delta_{Ni} - \phi_{Ni} \cong 1nm$; ϕ_{Ni} is the diameter of Ni atom; Δ_{Ni} is the *average molecular separation* in the Ni. Then, we get $n_H V_H = n_H S_f \delta_H \cong 6.4 \times 10^{18} atoms$. Thus, the total energy realized in the p-p fusions is

$$E = \frac{n_H V_H}{2}(0.42MeV) =$$
$$= \frac{6.4 \times 10^{18}}{2}(0.42MeV) = 1.3 \times 10^{24} eV \cong$$
$$\cong 2.1 \times 10^5 J \cong 0.05\ Kwh$$

This energy correspond to a power of $0.05Kwh/h = 50W$, which is the same value detected in the *Focardi's* experiments.

This explains the anomalous heat production in Ni-H Systems detected in the *Focardi's* experiments.

Since the 7.83 Hz electromagnetic field (Schumann resonances) *does not disappear when the device is switched off, the energy conversion can remain running for long period after it is switched off* because, when the device is switched off, the value of the electrical conductivity of the Ni-H system, which was approximately equal to σ_{Ni}, slowly decreases, tending to σ_H, which is much smaller than 1. When the electrical conductivity becomes smaller than $\omega\varepsilon$ the value of n_r becomes approximately equal to 1. Consequently, λ_{mod} becomes equal to $c/f = 3.8 \times 10^7 m$ and, according to Eq.(17), the result is $\chi \cong 1$.

This explain why in the Focardi's experiment the device remained running for twenty four days after being switched off.

It is evident that the discovery of this energy conversion device is highly relevant. However, this system is not an efficient energy source if compared to the *Gravitational Motor* [18], which can provide

219KW/m^3 while the Ni-H system only 20Kw/m^3 (by increasing α from 5cm up to 100cm). Furthermore, the Gravitational Motor converts gravitational energy into rotational mechanical energy directly from the gravitational field, while the Ni-H system needs to produce vapor in order to convert the energy into rotational mechanical energy.

3. Transforming a Ni-H system into a Hydrogen Bomb.

It is easy to see that a Ni-H System can be transformed into a Hydrogen bomb, simply increasing the volume of the Ni-H cylinder and substituting the Hydrogen by *a liquid deuterium* LD (12.5 MeV of *energy* is produced at each fusion of two *deuterium nuclei* ‡). For example, if α = 0.27m, ξ = 2 m, and, if a liquid deuterium ($\rho_H = 67.8 \ kg.m^{-3}$ [19]) is injected into the Ni powder, then the total energy realized in the fusions becomes

$$E = \frac{n_H V_H}{2}(12.5 MeV) =$$
$$= \frac{8.4\times10^{24}\rho_H \alpha^2 \xi}{2}(12.5 MeV) \cong \qquad (2)$$
$$\cong 5.2\times10^{31}\rho_H \alpha^2 \xi \ eV \cong 8.2\times10^{13} J \cong 20 \ kilotons$$

The Hiroshima's atomic bomb had *20 kilotons*.

It is important to note that *this bomb type is much easier to build than the conventional nuclear bombs*. Basically, these bombs are made of *Nickel powder* (99%), *liquid deuterium-tritium mixture* and *Mumetal*. These materials can be easily obtained. Due to the simplicity of its construction *these bombs can be built at the very place of the target* (For example, *inside a house or apartment at the target city*.). This means that, in the most of cases missiles are not necessary to launch them. In addition, they cannot be easily detected during their building because the necessary materials are trivial, and there is no radioactive material.

‡ The $d + d$ fusion reaction has two branches that occur with nearly equal probability: ($T + p$ + 4.03MeV and $^3He + n$ + 3.27MeV). Then, a *deuteron d* is produced by the fusion of the proton p (produced in the first branch) with the neutron (produced in the second branch). Next, occurs the fusion of this deuteron with the *tritium T* produced in the first branch, i.e., ($d + T \rightarrow {}^3_2He + n$ + 17.6 MeV). Thus, we count the $d + d$ fusion energy as E_{fus} = (4.03+17.6+3.27)/2 = 12.5 MeV.

References

[1] Fleischmann M., Hawkins, M. and Pons S., (1989) J. Electroanal. Chem., **261**, 301.

[2] Focardi, S., Habel, R. and Piantelli, F., (1994) *Nuovo Cimento* A, **107**, 163.

[3] Cerron-Zeballos et al., (1996) *Nuovo Cimento* A, **109**, 1645.

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

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

[6] Schumann W. O. (1952). "Über die strahlungslosen Eigenschwingungen einer leitenden Kugel, die von einer Luftschicht und einer Ionosphärenhülle umgebenist". *Zeitschrift und Naturfirschung* **7a**: 149–154

[7] Volland, H. (1995), *Handbook of Atmospheric Electrodynamics*, CRC Press, vol.I, Chapter11.

[8] Lin Li and Chung D.,(1991) *Composites*, **22**, 3, p.212.

[9] Göktürk, H., et al., (1993) J. App. Polymer Science, **50**, p.1900.

[10] Halliday, D. and Resnick, R. (1968) *Physics*, J. Willey & Sons, Portuguese Version, Ed. USP, p.1124.

[11] Neikov, O.D, et al., (2009) *Handbook of Non-Ferrous Metal Powders: Technologies and Applications*, Elsevier Ltd., p.374.

[12]Selembo, P. A, et al., (2010) *Hydrogen production with nickel powder cathode catalysts in microbial electrolysis cells*, International Journal of Hydrogen Energy, **35**, p. 431, p.433.

[13] Park T. S. et al., (1998) Astrophys. J. 507 443.

[14] Kong X and Ravndal, F. (1999) Nucl. Phys. A 656 421; Kong X and Ravndal, F. (1999) Phys. Lett. B 470, 1; Kong X and Ravndal (2001) F. Phys. Rev. C 64 , 044002.

[15] Butler. M. and Chen, J. W., (2001) Phys. Lett. B 520 , 87.

[16] Park T. S. et al., (2003) Phys. Rev. C 67 055206 (nucl-th/0208055); Park T. S. et al., nucl-th/0106025 and nucl-th/0107012.

[17] Battaglia, A. et al., (1999) *NuovoCimento* A, **112**, 921.

[18] 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, Physics /0701091.

[19] Rossini, F.D. (1968) *IPTS-1968*, Butterworths, London.