Ed: On request from New Energy Times in 2012 , Vysotskii was unable to provide any scientific reference to support his assertion of "important Rossi-Focardi experimental results." This paper, therefore, has no factual basis and we present is as an example of unscientific skepticism. - New Energy Times

Critique of the Widom-Larsen Theory

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Abstract: A quantitative dynamical analysis of the Widom-Larsen theory reveals some significant problems with that approach to explaining low-energy nuclear reactions.

Introduction

Theoretical explanation of important Rossi-Focardi (R-F)[1,2] experimental results are often associated with Widom-Larsen (W-L) theory.[3-8] However, there is no detailed analysis of the possibility of application of this theory to real experiments. Some aspects of such analysis are presented below.

In W-L works[3,4] the process of optimization and acceleration of low-energy nuclear reactions by the use of inverse reaction of beta-decay in the area of existence of surface plasmon on the surface of palladium or nickel matrix was considered. The general scenario of such process is based on three consecutive steps:

• process of increase of electron mass by "dressed up" effect (renormalizing) and formation of heavy electrons with $\Delta m_e > 0$ by ponderomotive nonlinear action of variable electric field of surface plasmon;

• transformations of protons, which are situated in the form of hydrogen atoms on a surface of palladium or nickel matrix, into slow neutrons in inverse reaction of beta-decay

$$\tilde{e}^- + p \rightarrow n + \nu,\ \tilde{m}_e \equiv m_e + \Delta W/c^2,\ \Delta W = \Delta m_e c^2 > |Q_{e^-p}|, Q_{e^-p} \approx -0.78 \text{ MeV} \quad (1)$$

with the help of "dressed up" heavy electrons;

• immediate absorption of these slow neutrons in a matrix and stimulations of non-barrier nuclear reactions of neutron capture, nucleus fission or neutron stimulated nucleus transmutation

$$n + {}_Z X^A \rightarrow {}_Z X^{*A+1} \rightarrow {}_{Z_1}Y^{A_1} + {}_{Z-Z_1}K^{A-A_1} + N\gamma + \Delta Q \rightarrow \ldots \quad (2)$$

with the release of energy $\Delta Q > 0$.

The W-L theory of change of energy of inverse beta-decay reaction from initial negative value $Q_{e^-p} \approx -0.78$ MeV to final positive value $Q_{e^-p} > 0$ at such ponderomotive action was proposed and considered in two W-L papers.[3,4] In these works it was predicted that such process is possible with the result of electron mass increase ("dressed up" effect with $\Delta m_e > 0$) and without the change of electron momentum by the use of variable electric field of surface plasmon.

The general idea of such method is very attractive. Its ideological part is close to the well-known process of inverse beta-decay reaction $\Delta W + e^- + {}_Z X^A \rightarrow {}_{Z-1}Y^A + \nu$, which takes place during the neutronization process that is stimulated by gravitational collapse of stars with masses $M > 1.45\ M_\odot$ and leads to the formation of neutron stars ($M_\odot$ is the mass of the Sun). This process is connected with the increase of Fermi energy $W_F \equiv (3\pi^2)^{1/3}\hbar c n_e^{1/3} \geq (M_{(A,Z-1)} - M_{(A,Z)} - m_e)c^2$ of relativistic degenerate electron gas with electron number density $n_e \geq m_e^3 c^3/3\pi^2\hbar^3 \approx 10^{30}$ cm^{-3} during gravitational collapse. Both processes (W-L and the process of astrophysical neutronization, AN) are connected with the increase of electron energy but in different ways:

a) The AN process is connected with the formation of relativistic electrons with great momentum $p_e = \sqrt{\gamma^2 - 1}\ m_e c \geq m_e c$ and great relativistic energy $W_e = \gamma m_e c^2$;

b) The predicted W-L process is connected with the formation of fixed or slow "dressed up" heavy electrons with low momentum $p_e << m_e c$, great renormalized mass and great energy $W_e = \tilde{m}_e c^2$.

The AN process is real and plays a very important role in the evolution of the Universe. Reality of the W-L process in R-F experiments will be discussed below. Moreover, in the same way the reaction of safe controlled stimulated nuclear fission of ${}_{92}U^{235}$

$$n + {}_{92}U^{235} \rightarrow {}_{Z_1}Y^{A_1} + {}_{92-Z_1}K^{236-A_1-N} + Nn + \Delta Q,\ \Delta Q \approx 200 \text{ MeV},\ N \approx 2-3 \quad (3)$$

on the surface of hydride of natural uranium may be predicted. Such reaction can occur during the interaction of ${}_{92}U^{235}$ isotope with slow neutrons, created during similar neutronization of hydrogen atoms adsorbed on a surface of natural uranium.

The natural concentration of ${}_{92}U^{235}$ isotope is $\eta = 0.72\%$. If we use the estimation[4] $\tilde{w}(\tilde{e}^- p \rightarrow n\nu) \approx 10^{13}$ cm^{-2}s^{-1} for the surface intensity of generated neutrons at the surface density of the adsorbed hydrogen $N/S = 10^{16}$ cm^{-2}, then the release of the surface power density in such reaction may reach the value

$$P/S = \tilde{w}(\tilde{e}^- p \rightarrow n\nu)\alpha\Delta Q \approx 300 \text{ W/cm}^2 \quad (4)$$

Here

$$\alpha = \frac{\eta\sigma_{nf}^{235}}{\eta\sigma_{nf}^{235}(1 + \sigma_{n\gamma}^{235}/\sigma_{nf}^{235}) + (1-\eta)(\sigma_{nf}^{238} + \sigma_{nf}^{238})} \approx 0.84$$

is the probability of single fission reaction at the interaction of slow neutron with uranium nucleus; $\sigma_{nf}^{238} \approx 0$, $\sigma_{n\gamma}^{238} \approx 2.8$ *bn*, $\sigma_{n\gamma}^{235}/\sigma_{nf}^{235} \approx 0.19$, $\sigma_{n\gamma}^{235} > 1000bn$ are the cross-sections of fission (n,f) and capture (n,γ) reactions for $_{92}U^{235}$ and $_{92}U^{238}$ isotopes for thermal neutrons.

Actually, in such a real "natural uranium+hydrogen" system, the activity of accompanied gamma-radiation may exceed $Q/S \geq 10^4$ Curie/cm^2.

The same or more gamma- and X-activity has to be registered in all similar processes with neutron capture (*e.g.*, in Rossi experiments with power release $P \approx 10$ kW expected activity may exceed the fantastic value $Q \geq 10^{17} - 10^{18}\ Bq \approx 3.10^7 - 3.10^7$ Curie).

On the other hand, nobody observed such radiation effects in real metal hydrides (including Rossi experiments and "natural uranium+hydrogen" systems). The main question is the following: Are such processes of stimulated inverse beta-decay reaction in metal hydrides possible?

More detailed analysis shows that for conditions of real experiments with metal hydride, the W-L method is very inefficient and cannot explain observable effects (in particular, effects connected with R-F experiments). The small probability of such process in metal hydrides, first of all, is connected with peculiarities of the action on electrons of strong variable vector potentials. Presence of such variable (periodical) potentials leads to the formation of a strong electric field, which acts on electrons. Influence of spatially uniform periodical fields (*e.g.*, plane waves) leads to periodical electron oscillations with limited magnitude and averaged renormalization of electron mass. Influence of spatially nonuniform periodical fields (*e.g.*, surface plasmons or short laser impulse) leads to the acceleration of electrons and to their moving out from the area of non-uniform field localization.

Let us consider the reality of physical processes that take place during consecutive stages of realization of W-L theory in application to conditions of R-F experiments.

Influence of Electron Motion on the Electric Field of Surface Plasmons of Metal Hydrides

In W-L works,[3,4] it was supposed that surface electrons of metal hydride are under the influence of strong variable electric field $\vec{E}(\vec{r},t) = \vec{E}_0(\vec{r})\cos\Omega t$ with intensity $<|\vec{E}_0^{(max)}|> \approx en_p^{2/3} \approx 10^{10}$ V/cm and frequency $\Omega = \omega_p \approx 10^{13}$ s^{-1}, generated by plasma fluctuations of ions with concentration n_p. On the other hand, it is implicitly supposed that these electrons do not react with the field $\vec{E}(\vec{r},t)$, do not change their own (electron) state of motion under the influence of the field $\vec{E}(\vec{r},t)$ and do not influence this field. This means that the authors[3,4] have used the assumption of a invariance of the electron state due to periodical oscillations of surface nuclei (protons) near the equilibrium position.

According to the general concepts of quantum mechanics and quantum statistics, such assumption corresponds to the condition of ideality of degenerated electron gas, when average kinetic electron energy

$$\bar{T}_e = (3/5)E_F = \frac{3(3\pi^2)^{2/3}\ \hbar^2 n_e^{2/3}}{10m_e} \tag{5}$$

exceeds greatly the average potential energy

$$|\bar{V}_e| \equiv < Ze^2/r > = \frac{3Z^{2/3}e^2 n_e^{1/3}}{2}\left(\frac{4\pi}{3}\right)^{1/3} \tag{6}$$

of the same electron.

This condition $\bar{T}_e >> |\bar{V}_e|$ is satisfied only in degenerate electron gas with very high electron concentration

$$n_e >> \left(\frac{m_e e^2}{h^2}\right)^3 Z^2 \approx 10^{25} Z^2\ \text{cm}^{-3} \tag{7}$$

In the same work,[4,Eq.24] the following expression for electron density was used: $n_e = 1/\pi\alpha^3 \approx 3.10^{23}$ cm^{-3}, which corresponds to the opposite condition $\bar{T}_e < |\bar{V}_e|$. More exact analysis based on virial theorem shows that in an atom of hydrogen the similar opposite condition $\bar{T}_e = 0.5|\bar{V}_e|$ takes place.

Because of the breaking of the condition of electron gas ideality, the situation significantly changes in comparison with assumptions used in W-L.[3,4] In this case, electrons (as easier particles) move much faster than protons and immediately react to the breaking of both local charge equilibrium and formation of additional local electric field $\vec{E}(\vec{r},t)$ during plasma oscillation. Motion of electrons leads to the adiabatic compensation of electric field $\vec{E}(\vec{r},t)$ connected with the motion of protons. From plasma theory it follows that any local nonequilibrium in plasma exists for no more than the period $T_e = 2\pi/\omega_e$ of electron plasma frequency $\omega_e = \sqrt{4\pi n_e e^2/m_e}$. In metals $T_e \approx (1...3)*10^{-16}$ s that is 100-1000 times less than the period $T_p = 2\pi/\omega_p$ of heavy ion (proton) plasma frequency $\omega_p = \sqrt{4\pi n_p e^2/M_p}$. The same effect takes place for surface plasmon oscillations. For such relation of T_e and T_p, all electrons in plasma and in metals always follow the protons, and movement of protons is close to adiabatic.

Hence, actual electric fields in the volume of ionic surface plasmon is by many orders (in $\omega_e/\omega_p = \sqrt{n_e M_p/m_e n_p} >> 1$ times) less than the value $<|\vec{E}_0^{(max)}|> \approx en_p^{2/3} \approx 10^{10}$ V/cm predicted in W-L.[3,4]

Another approach also shows that this electric field is much lower than the predicted value $<|\vec{E}_0^{(max)}|> \approx 10^{10}$ V/cm, which is based on the analysis of the method of $E_0^{(max)}$ calculation used in W-L.[4]

In this work, the main model was connected with a proton embedded in a sphere with a mean electronic charge density $\rho_e = -en$. It is the standard Wigner-Zeitz cell. If the proton suffers a small displacement u then an electric field $\vec{E}(\vec{r})$ will appear[4,Eq.22]

$$div\vec{E}(\vec{r}) = 4\pi\rho_e,\ E(r) = \frac{4\pi}{3} r\rho_e = -\frac{4\pi}{3} enr,\ \vec{r} \equiv \vec{u} \tag{8}$$

The strength of the mean electric field in W-L[4]

$$|E(u)| = \frac{4e}{3\alpha^3} u = E_{atom}(\alpha)\left(\frac{4}{3}\right)\frac{u}{\alpha} E_{atom}(\alpha) = e/\alpha^2 \approx 5.1*10^9\ \text{V/cm} \tag{9}$$

was estimated by taking the mean electron number density at the position of the proton[4,Eq.24,26]

$$n\ (r = 0) = |\Psi_{1s}(0)|^2 = \frac{1}{\pi\alpha^3},\ \alpha \equiv r_B = \frac{\hbar^2}{m_e e^2} = 5.3*10^{-9}\ \text{cm} \tag{10}$$

The next calculation of electric field was made in W-L[4] based on these formulas. From neutron scattering experiments on palladium hydride it follows that the amplitude of collective proton oscillations on palladium surface equals $\bar{u}_p$

≈ 2.2 A.[4] At such a value $\bar{u}_p$ the mean electric field was estimated through Equation 10[4,Eq.26] and equals[4,Eq.27]

$$|E(r = \bar{u}_p)| = E_{atomic}(\alpha)\left(\frac{4}{3}\right)\frac{\bar{u}_p}{\alpha} \approx 2.9*10^{10}\ \text{V/cm} \qquad (11)$$

This is an incorrect estimation. Equation 9 is correct only for very small displacements $u << \alpha$ and at $\bar{u}_p << \alpha$ (see expression for $n(r = 0)$ in Equation 10). If $\bar{u}_p > \alpha$, we need to use the correct (screened) expression for mean electron number density at the position of the proton

$$|E(r \approx \bar{u}_p)| = -\frac{4\pi}{3} er|\Psi_{1s}(r)|^2 \Big|_{\bar{u}_p} = -\frac{4e}{3\alpha^3}\bar{u}_p\, e^{-2\bar{u}_p/\Lambda} = -E_{atomic}(\alpha)\left(\frac{4}{3}\right)\frac{\bar{u}_p}{\alpha} e^{-2\bar{u}_p/\Lambda} \qquad (12)$$

Here Λ is a radius of electron screening:

$$\Lambda_B = \hbar^2/m_e e^2 = 0.53\ \text{A (for atom)} \qquad (13)$$

$$\Lambda = \Lambda_D = \sqrt{kT/4\pi\bar{n}e^2}\ \text{(for classical Boltzman electron gas at } kT > \varepsilon_F)$$

$$\Lambda_{TF} = \sqrt{\varepsilon_F/3\pi\bar{n}e^2}\ \text{(for degenerate electron gas at } kT < \varepsilon_F)$$

In all metals (including Ni) $\varepsilon_F \approx 4...6$ eV ≈ 40000...60000 K and $\Lambda = \Lambda_{TF} \approx 0.6$ A. For such parameters we have $|E(r \approx \bar{u}_p)| \approx 2.10^7$ V/cm, that is too low for the formation of heavy "dressed" electrons needed for inverse reaction of beta-decay (Equation 1).

Effectiveness of Neutron Production by Inverse Beta-decay Due to Ponderomotive Action of Variable Electric Fields from Surface Plasmons

From the general principles of relativistic mechanics and electrodynamics it follows that the canonical 4-momentum $p_\mu = \{i\frac{\varepsilon}{c}, \vec{p}\}$ of charge q in the presence of 4-potential $A_\mu = \{i\varphi, \vec{A}\}$ changes to the form $p_\mu \to p_\mu - \frac{q}{c}A_\mu$. As a result, the total energy of an electron with the charge $q = -e$, with the rest mass m_e, with original small initial momentum $\vec{p}$ and at the presence of variable electromagnetic field is given by

$$W_{tot} = \left\{(m_e c^2)^2 + \sum_{\mu=1}^{3}(p_\mu + \frac{e}{c}A_\mu)^2 c^2\right\}^{1/2} \qquad (14)$$

$$\approx \left\{(m_e c^2)^2 + e^2|\vec{A}(\vec{r},t)|^2\right\}^{1/2} = \left\{(m_e c^2)^2 + e^2c^2|\vec{E}(\vec{r},t)|^2/\Omega^2\right\}^{1/2}$$

Here $\vec{A}(\vec{r},t) = \vec{A}_0(\vec{r})\sin\Omega t$ and

$$\vec{E}(\vec{r},t) = \frac{1}{c}\frac{\partial\vec{A}(\vec{r},t)}{\partial t} = (\Omega/c)\vec{A}_0(\vec{r})\cos\Omega t \equiv \vec{E}_0(\vec{r})\cos\Omega t$$

are vector-potential and electric field intensities generated by plasma oscillation of ions (protons) situated on the metal surface.

According to the data of W-L,[3,4] the energy of the ponderomotive interaction of this field with an electron

$$W_{pond}(\vec{r},t) = \left\{(m_e c^2)^2 + e^2c^2|\vec{E}(\vec{r},t)|^2/\Omega^2\right\}^{1/2} - m_e c^2 \qquad (15)$$

is much greater then the binding energy

$$W_{coulomb} = Ze^2 e^{-r/\alpha}/r \qquad (16)$$

of an electron with nucleus and equals $W_{pond}^{(max)} \approx 1$ MeV.

The action of spatially-non-uniform periodic ponderomotive force on electrons

$$\vec{F}_{pond}(\vec{r},t) = -\nabla\vec{W}_{pond}(\vec{r},t) = -\frac{(ec/\Omega)^2\nabla|\vec{E}(\vec{r},t)|^2}{2\left\{(m_e c^2)^2 + e^2c^2|\vec{E}(\vec{r},t)|^2/\Omega^2\right\}^{1/2}} \qquad (17)$$

which is synchronized with the variable electric field $\vec{E}(\vec{r},t)$, leads to their acceleration and expulsion from the area of an increasing field.

Such an effect is used for the formation of a group of relativistic electrons with energy $T_e \geq 100$ - 300 MeV due to the action of femtosecond laser pulses on a solid-state matrix. In this case, the increase of electron energy $W_e = \gamma m_e c^2$ is connected with the increase of relativistic momentum $p_e = \sqrt{\gamma^2 - 1}\, m_e c$ instead of formation of "dressed up" electron with $W_e = \tilde{m}_e c^2$ and low momentum $p_e << m_e c$.

The alternative effect, namely increase of the effective mass of this electron $m_e \to \tilde{m}_e$ without acceleration (without increase of electron momentum) due to ponderomotive nonlinear interaction with electric field (effect of "dressed up" electron), is possible only in the case of completely spatial-homogeneous variable field $\vec{E}(\vec{r},t) \equiv \vec{E}(t)$, when there is no pushing-out force and $\vec{F}_{pond} \sim \nabla|\vec{E}(\vec{r},t)|^2 \equiv 0$.

However, in the considered model of the surface plasmon, the field $\vec{E}(\vec{r},t)$ is extremely non-uniform (*e.g.*, $\vec{E}(\vec{r},t) = \vec{e}_x E_0 e^{-xn_p^{1/3}}\cos\Omega t$). In this case, the ponderomotive force equals

$$F_{pond} \approx \frac{ecn_p^{1/3}|\vec{E}(\vec{r},t)|}{\Omega}\left\{1 - \frac{m_e^2c^2\Omega^2}{2e^2|\vec{E}(\vec{r},t)|^2}\right\} \text{ if } |\vec{E}(\vec{r},t)| > \frac{\Omega m_e c^2}{ec} \qquad (18a)$$

and

$$F_{pond} \approx \frac{e^2 n_p^{1/3}|\vec{E}(\vec{r},t)|^2}{m_e\Omega^2}\left\{1 - \frac{e^2|\vec{E}(\vec{r},t)|^2}{2m_e^2c^2\Omega^2}\right\} \text{ if } |\vec{E}(\vec{r},t)| < \frac{\Omega m_e c^2}{ec} \qquad (18b)$$

The action of a non-uniform electric field $E(\vec{r},t) = E_0 e^{-xn_p^{1/3}}\cos\Omega t$ with magnitude $E_0 = \delta\Omega\, m_e c^2/ec$ on an electron, satisfies (Equation 18b) with $\delta << 1$, so the equation of electron motion has the form

$$m_e\frac{d^2x}{dt^2} = F_0 e^{-2xn_p^{1/3}}\cos^2\Omega t,\ F_0 = \delta^2 m_e c^2 n_p^{1/3} \qquad (19)$$

with boundary conditions x(0) = 0, $dx/dt|_0 = 0$.

Let us consider first a simpler equation of electron motion due to the action of stationary non-uniform force $F_0 e^{-2xn_p^{1/3}}$:

$$m_e\frac{d^2x}{dt^2} = F_0 e^{-2xn_p^{1/3}} \qquad (20)$$

that has the solution

$$\frac{dx}{dt} = \delta c\sqrt{1 - \exp(-2xn_p^{1/3})}. \qquad (21a)$$

In this case, the duration τ of electron motion for distance $n_p^{-1/3}$ (duration of electron pushing-out from the area of the strong action of the ponderomotive force) equals

$$\tau = \int_0^{n_p^{-1/3}}\frac{dx}{dx/dt} = \frac{arcs\sqrt{e}}{\delta c n_p^{1/3}} \approx \frac{1.65}{\delta c n_p^{1/3}} \qquad (22a)$$

At $n_p \approx 3.10^{22}$ cm^{-3} and $\delta = 0.1$, we have very short duration of motion $\tau = 2.10^{-17}$ s, which is 10^4 times less than the period of plasma oscillation $T_p = 2\pi/\omega_p$. As the result of such adiabaticity, the final solutions of the equation of electron motion (Equation 19) are similar to Equations 21a and 22a:

$$\frac{dx}{dt} \approx \delta c\, |\cos\Omega t| \sqrt{1 - \exp(-2xn_p^{1/3})} \qquad (21b)$$

$$\tau = \int_0^{n_p^{-1/3}} \frac{dx}{dx/dt} = \frac{arcsh\sqrt{e}}{\delta c n_p^{1/3}} \approx \frac{1.65}{\delta c|\cos\Omega t| n_p^{1/3}} \qquad (22b)$$

Hence, the main result of the ponderomotive action of a strong non-uniform variable electric field $\vec{E}(\vec{r},t)$ due to surface plasmons is the acceleration of both free conduction electrons and coupled atom electrons.

Now, let us consider the efficiency of inverse beta-decay $\tilde{e}^- p \to n\nu$ taking into account the formation of such accelerated relativistic electrons.

The mean free path of these fast electrons in relation to the process of inverse beta-decay $\tilde{e}^- p \to n\nu$ is

$$< l_{\tilde{e}^- p \to n\nu} > \approx < v > \tau_{\tilde{e}^- p \to n\nu} \qquad (23)$$

Here $\tau_{\tilde{e}^- p \to n\nu} = 1/\Gamma_{\tilde{e}^- p \to n\nu}$ is the duration of return beta-decay reaction[3,Eq.29,30]

$$\Gamma(\tilde{e}^- p \to n\nu) \approx (G_F m_e^2 c/\hbar^3)^2 (m_e c^2)/\hbar) \left(\frac{\tilde{m}_e - \Delta}{\Delta}\right)$$
$$\approx 1.2*10^{-3}(\beta - \beta_0)^2 \text{ s}^{-1}, \qquad (24)$$
$$\beta = \tilde{m}_e/m_e,\ \Delta = M_n - M_p \approx 1.3 \text{ MeV}/c^2$$

On the other hand, the same mean free path may be written using the cross-section $\sigma_{\tilde{e}^- p \to n\nu}$ of $\tilde{e}^- p \to n\nu$ reaction and total concentration n_t of atoms (nuclei) in target

$$< l_{\tilde{e}^- p \to n\nu} > \approx 1/\sigma_{\tilde{e}^- p \to n\nu} n_t \qquad (25)$$

From the last the equations it follows that the cross-section $\sigma_{\tilde{e}^- p \to n\nu}$ for return beta-decay reaction with the participation of fast electron with averaged velocity $< v >$ is

$$\sigma_{\tilde{e}^- p \to n\nu} \approx \Gamma_{\tilde{e}^- p \to n\nu}/n < v > \approx \left\{1.2*10^{-3}(\beta - \beta_0)^2/n < v >\right\} \text{cm}^2 \qquad (26)$$

For typical parameters $n_t \approx 3*10^{22}$ cm^2, $< v > \approx c/3 = 10^{10}$ cm/s, $\beta - \beta_0 \approx 0.5$ we have

$$\sigma_{\tilde{e}^- p \to n\nu} \approx \Gamma_{\tilde{e}^- p \to n\nu}/n < v > \approx 10^{-36} \text{ cm}^2 = 10^{-12}\ bn, \qquad (27)$$

$$< l_{\tilde{e}^- p \to n\nu} > \approx 3*10^{13} \text{ cm} \qquad (28)$$

This cross-section of neutronization is 10^{14} - 10^{15} times less than the cross-section $\sigma_{ion.rad.loss} = 1/n_t < l_{ion.rad.loss} >$ for ionization and radiative loss (including ionization and excitation of atoms of target and X-ray bremsstrahlung). In particular, for an electron with energy about 0.8 MeV, the mean free path in Ni or Pd matrix is about $< l_{ion.rad.loss} > \approx 1...2$ mm and

$$\sigma_{ion.rad.loss} \approx (3 - 1.5)*10^{-22} \text{ cm}^{-2} = 300 - 150\ bn \qquad (29)$$

As a result, at surface density of heavy electron-proton pairs $N/S = 10^{16}$ cm^{-2}, the maximal possible rate of neutron production on a metal hydride surface is much lower than was presented in W-L[4] (see Equation 31 where $\tilde{w}(\tilde{e}^- p \to n\nu) \approx 10^{13}$ cm^{-2}s^{-1} at $\beta - \beta_0 \approx 0.5$) and equals to the very low value

$$\tilde{w}(\tilde{e}^- p \to n\nu) \approx 1.2*10^{13} (\beta - \beta_0)^2 \frac{< l_{\tilde{e}^- p \to n\nu} >}{< l_{ion.loss} >} \text{cm}^{-2}\text{s}^{-1} \le 0.03 \text{ cm}^{-2}\text{s}^{-1} \qquad (30)$$

The Problem of Additional Localized Energy for the Generation of Heavy Electrons

According to the Fermi theory of weak interactions, the rate of $\tilde{e}^- p \to n\nu$ reaction is the following[3,Eq.29,30]

$$\Gamma(\tilde{e}^- p \to n\nu) \approx (G_F m_e^2 c/\hbar^3)^2 (m_e c^2)/\hbar) \left(\frac{\tilde{m}_e - \Delta}{\Delta}\right)^2$$
$$\approx 7*10^{-3}\left(\frac{\tilde{m}_e - \Delta}{\Delta}\right)^2 \text{s}^{-1} \approx 1.2*10^{-3}(\beta - \beta_0)^2 \text{ s}^{-1}, \qquad (31)$$

At surface density of heavy electron-proton pairs[4] $N/S = 10^{16}$ cm^{-2}, the rate of weak neutron production on a metal hydride surface is[4,Eq.31]

$$\tilde{w}(\tilde{e}^- p \to n\nu) \approx 1.2*10^{13} (\beta - \beta_0)^2 \text{ cm}^{-2}\text{s}^{-1} \qquad (32)$$

For formation of such surface density of heavy ("dressed up") electrons, we need additional density of:

- localized specific surface energy

$$W/S \ge (\tilde{m}_e - m_e)c^2(N/S) \ge 1.3*10^{16} \text{ MeV/cm}^2 \approx 2*10^3 \text{ J/cm}^2 \qquad (33)$$

- localized specific volume energy

$$(W/S)n_p^{1/3} \ge 10^{24} \text{ MeV/cm}^3 \approx 10^{11} \text{ J/cm}^3 \qquad (34)$$

- localized specific surface power

$$P/S \approx \tilde{w}(\tilde{e}^- p \to n\nu)(\tilde{m}_e - m_e)c^2 \approx 2*10^{13} \text{ MeV/cm}^2 \approx 3 \text{ W/cm}^2 \qquad (35)$$

- localized specific volume power

$$(P/S)\ n_p^{1/3} \approx 10^{21} \text{ MeV/cm}^3 \approx 3*10^8 \text{ W/cm}^3 \qquad (36)$$

There are no sources of such concentrated energy and power on the surface of a metal hydride.

A decrease of total proton mass (including the mass of proton electrostatic field) cannot be the source of this energy because in such case the conditions of inverse reaction of beta-decay (Equation 1) cannot be satisfied.

Systems similar to perpetuum mobile and Maxwell's demon are necessary for creation and concentration of such energy and power.

The thermal energy of these N/S surface hydrogen atoms is only

$$(3kT/2)N/S \le 4*10^{-5} \text{ J/cm}^{-2} \qquad (37)$$

The realistic maximum possible total number of heavy electron-proton pairs with additional energy $E \ge (\tilde{m} - m)c^2 \ge 0.8$ MeV at averaged (thermal) energy $kT \approx 0.025...0.075$ eV ($T = 300...900$ K) of each proton in the considered system is very small and equals

$$N^*/N = \int_{(\tilde{m}-m)c^2}^{\infty} \frac{1}{kT} e^{-E/kT}\, dE = e^{-(\tilde{m}-m)c^2/kT} \approx (10^{-14000000} \ldots 10^{-4500000}) \to 0,\ N^*/S \to 0 \qquad (38)$$

Such negligible surface concentration of heavy electron-proton pairs N^*/S does not explain observable effects.

Conclusions

The analysis has shown that the Widom-Larsen theory, which is connected with the inverse reaction of beta-decay in variable electric field of surface plasmon in real metal hydride, is very idealized. It does not consider the important features of interactions of electrons with strong non-uniform variable surface electric fields in condensed matter. It is unsuitable for description of Rossi-Focardi experiments in metal hydrides.

Methods for realization of inverse beta-decay may be effective for the action of uniform plane electromagnetic waves[9] of very high intensity $J \geq c\,|E_0^{(\max)}|^2 / 4\pi \approx 10^{20}$ W/cm^2 with uniform substances. Such intensities are reached in experiments with femtosecond laser pulses. Unfortunately, electromagnetic fields of such squeezed optical laser pulses are very non-uniform. In those cases, interaction of such pulses with any substance results in a pushing-out ponderomotive force and formation of relativistic electrons (*e.g.*, Vysotskii *et al.*[10]). The same effect of electron acceleration takes place due to interaction of external soft electromagnetic waves (*e.g.*, action of IR laser) with a metal surface in geometry discussed in W-L.[7] In that case, the surface electromagnetic field will be non-uniform because of total reflection. On the other hand, in the case of the action of stationary radiation of hypothetical X-ray and gamma-ray lasers[11] on a thin layer, the process of surface reflection is absent. Then, the electromagnetic field would be close to uniform and there would be no effect of acceleration.

It is possible also that the W-L model can be more effective in fully ionized systems containing only a very dense degenerated electron gas with bare nuclei and with small ionization loss, or in low-density totally ionized plasma of cosmic scale. Effectiveness of the W-L process in very strong magnetic fields (including generation of such fields in exploding wires[4,8] and during pinch-effect in very strong electric current) can be greater and needs additional investigation.

In our opinion, the best optimal method of optimization of low-energy nuclear reactions is connected with the formation of correlated states of interacting particles in nonstationary potential wells without the increase of total energy of these particles. This mechanism provides the great increase of very small sub-barrier transparency (10^{40} - 10^{100} and more times[12-14]) and can be efficiently applied to different experiments (*e.g.*, References 15-17 and Rossi-Focardi experiments).

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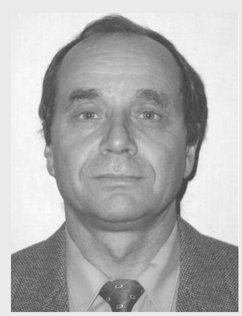
About the Author



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