Widom Larsen Theory

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Why Me?

- Widom Larsen Theory is currently considered by many in the government bureaucracy to explain LENR
- An informal discussion is probably worthwhile, particularly if Lew Larsen is not here
- I first met Lew Larsen when he was looking for Lockheed Martin funds to replicate an Ed Storms experiment at Sandia to assert its validity. We didn't make the LM cut.
- Later I invited Ed down to talk about CF experiments and was told I couldn't do that without clearing it with Lew first. (By Lew)
- I have met Lew on several occasions and have had dinner with Allan Widom once.
- The theory has a number of interesting aspects, and there have been no clear experiments to demonstrate its validity

Outline

- Weak Interaction Reactions
- Absorption of Nuclear Gamma Radiation by Heavy Electrons
- Prediction of Nuclear Abundances

Weak Interaction Reactions

$$e^- + p^+ \rightarrow n + \nu_e$$

$$M_n c^2 - M_p c^2 = 1.293\,MeV = 2.531\,M_e c^2$$

$$e^- + d^+ \rightarrow 2n + \nu_e$$

$$2M_n c^2 - M_d c^2 = 3.516\,MeV = 6.88\,M_e c^2$$

Electron Mass Increases Due to EM Field Fluctuations

- Colliding Laser Beams
- **EM fields on the surface of metal hydrides**
- Exploding wires
- Sunspot Tubes

Quasi-Classical Treatment

- Electron four momentum obeys the Hamilton Jacobi Equation
- Field fluctuations average to zero
- Mean square field fluctuations add mass to the electron
- Collective surface plasma modes range from the infrared to soft X-ray spectra
- Neutrons are born with ultra low momentum due to the size of the coherence domain of the oscillating protons

Hamilton Jacobi Equation

$$-(p_\mu - \frac{e}{c}A_\mu)(p^\mu - \frac{e}{c}A^\mu) = M_e c^2$$

$$-p_\mu p^\mu = \tilde{M}_e c^2 = M_e c^2 + \left(\frac{e}{c}\right)^2 \left\langle A^\mu A_\mu \right\rangle$$

$$\tilde{M}_e c^2 = \beta M_e c^2$$

Mass Renormalization

- The predicted mass renormalization by β is well known in solid state physics as it shifts thresholds
- The electron band energy enters into the kinematic energy conservation within condensed matter, not the vacuum electron energy
- Quantum electrodynamics gives the same result for β as the quasi-classical treatment

Surface Proton Oscillations on Metal Hydrides

- For a highly loaded metallic hydride, there will be a full proton layer on the surface

- The frequency scale of proton oscillations on the surface can be obtained from slow neutron scattering measurements

- The electric field on proton surface layer is typically 1.4×10^{11} volts/meter giving an RMS field fluctuation on the electrons of 2.88×10^{12} volts/meter

- For palladium this yields a value of $\beta = 20.6$

Neutron Production

- Neutrons are born with an ultra low momentum due to the size of the coherence domain of the oscillating protons
- Typical neutron wavelengths are 1 to 10 microns
- Either a pure proton or a pure deuteron surface layer is required to get the coherence
- An enforced chemical potential or pressure difference across the palladium surface will pack the surface layer to produce the coherent oscillations
- Laser light of the appropriate frequency can enhance the surface oscillations

Neutron Reactions

$${}^{6}_{3}Li + n \rightarrow {}^{7}_{3}Li + 7.25 MeV(\gamma) \quad \{1\}$$

$${}^{7}_{3}Li + n \rightarrow {}^{8}_{3}Li + 2.03 MeV(\gamma) \quad \{2\}$$

$${}^{8}_{3}Li \rightarrow {}^{8}_{4}Be + e^{-}(16.0 MeV) + \overline{\nu_{e}} \quad \{3\}$$

$${}^{8}_{4}Be \rightarrow 2{}^{4}_{2}He + 91.84 keV(KE) \quad \{4\}$$

$$\{5\} \quad {}^{4}_{2}He + n \rightarrow {}^{5}_{2}He + (-0.89\ MeV)$$

$$\{6\} \quad {}^{5}_{2}He + n \rightarrow {}^{6}_{2}He + 1.85\ MeV\ (\gamma)$$

$$\{7\} \quad {}^{6}_{2}He \rightarrow {}^{6}_{3}Li + e^{-}(3.0\ Mev) + \overline{\nu_{e}}$$

Absorption of Nuclear Gamma Radiation by Heavy Electrons

If Ultra Low Momentum neutrons react as described, there will be fairly hard gamma rays generated by reactions {1}, {2}, and {6}.

Hard gammas have not been observed.

Oscillations of heavy electrons on the surface of metallic hydrides suppress emission of hard gammas

Soft Photon Absorption in Metals

$$\frac{1}{L} = \frac{4\pi\sigma}{c} = R_{vac}\,\sigma$$

$$\frac{R_{vac}}{4\pi} = 29.97925 \ Ohm$$

$$\sigma^{-1} \le 10^{-5}\,Ohm - cm$$

$$L \le 3x10^{-8}\,cm$$

Hard Photon Absorption in Metals

The energy spread of heavy electron hole pair excitations implies that a high conductivity near the surface can persist well into the MeV photon energy range strongly absorbing prompt gamma radiation.

An absorbed hard gamma photon can be re-emitted as a very large number of soft photons.

Physical Kinetics
(Lifshitz and Pitaevskii)

$$\sigma_{he} \approx \frac{1}{\left(3\pi^2\right)^{1/3}} \left(\frac{e^2}{\hbar}\right) \left(\tilde{n}_{he}^{2/3}\, \tilde{l}_{he}\right)$$

$$\tilde{n}_{he}^{2/3} \approx 10^{15} / cm^2, \qquad \tilde{l}_{he} \approx 10^{-6} cm$$

$$\frac{1}{L_\gamma} \approx \frac{4}{137} \left(\frac{\pi}{3}\right)^{1/3} \tilde{n}_{he}^{2/3}\ \tilde{l}_{he}$$

$$L_\gamma \sim 3.4\, x 10^{-8}\, cm$$

Nuclear Abundances

- Ultra Low Momentum neutrons will continue to react on the surface of metal hydrides and build up the mass numbers of nuclides
- The cross section for absorption is so large that the Ultra Low Momentum neutrons will not exist outside of the surface layer on the metal hydrides
- The variation of the very large cross sections across mass number A can be predicted by a nuclear optical potential

Optical Potential

$$R = aA^{1/3}, \qquad a \approx 1.2x10^{-13}\,cm$$

$$U(r > R) = 0, \qquad U(r < R) = -\left(V + \frac{i\hbar\Gamma}{2}\right)$$

$$\left(\frac{\hbar^2}{2M}\nabla^2 + U(r)\right)\psi(r) = E\psi(r) = \frac{\hbar^2 k^2}{2M}\psi(r)$$

$$\psi(r) \rightarrow e^{ikr} + F(k,\theta)\frac{e^{ikr}}{r} + \ldots\ldots\ldots\ldots$$

$$\sigma_{total(k)} = \frac{4\pi}{k}\,\mathrm{Im}\{F(k,0)\}$$

$$\lim_{k\rightarrow 0}\,\mathrm{Im}\left\{\frac{\mathrm{Im}\,F(k,0)}{a}\right\} = f(A)$$

Optical Potential (2)

$$f(A) = \mathrm{Im}\left\{\frac{\tan(zA^{1/3})}{z}\right\}$$

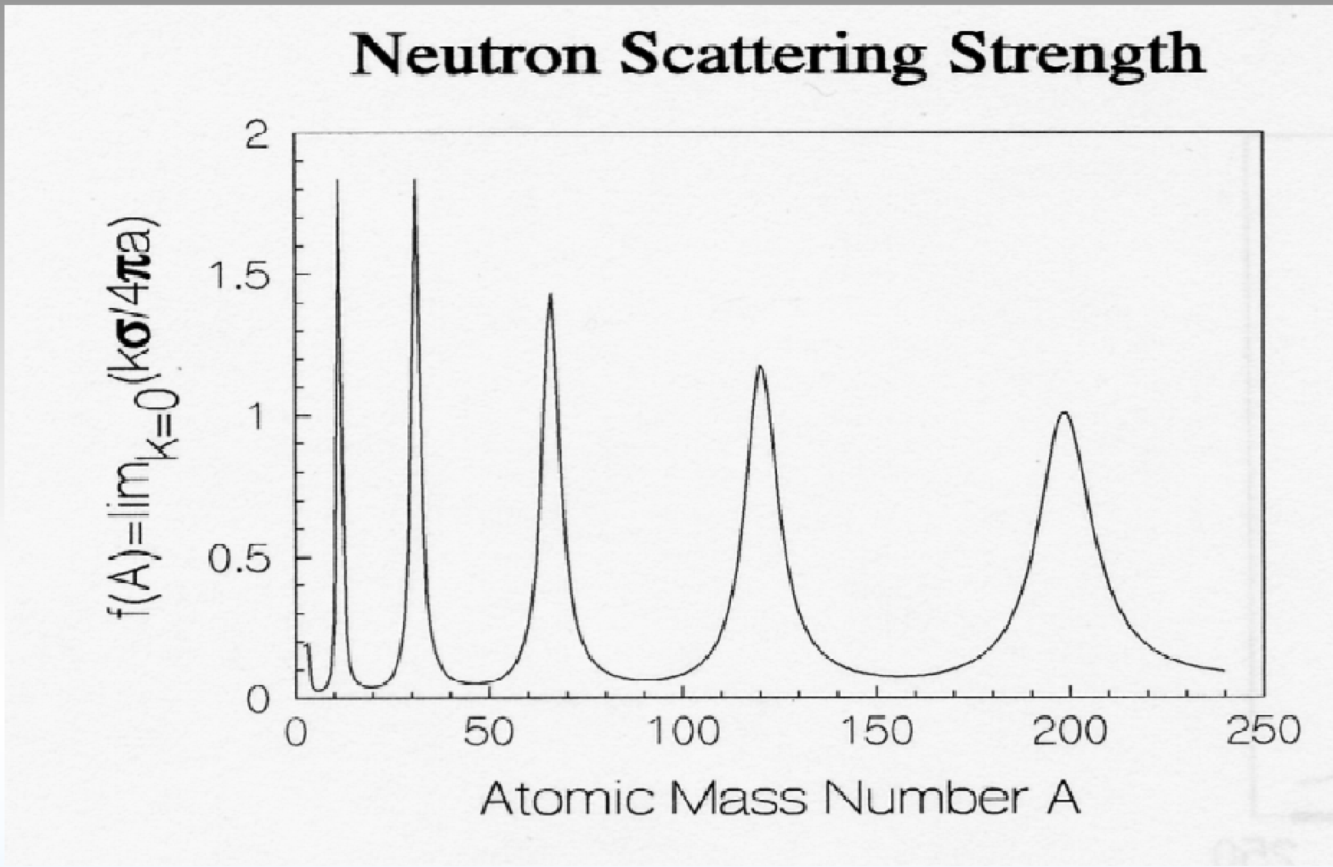
$$\frac{\hbar z}{a} = \left[2M\left(V + \frac{i\hbar\Gamma}{2}\right)\right]^{1/2}$$

$$\sigma_{total}(k, A) = \left(\frac{4\pi a}{k}\right) f(A), \qquad k \to 0$$

Choose

$$z = 3.5 + 0.05i$$

Optical Potential (3)



Miley’s Experiments

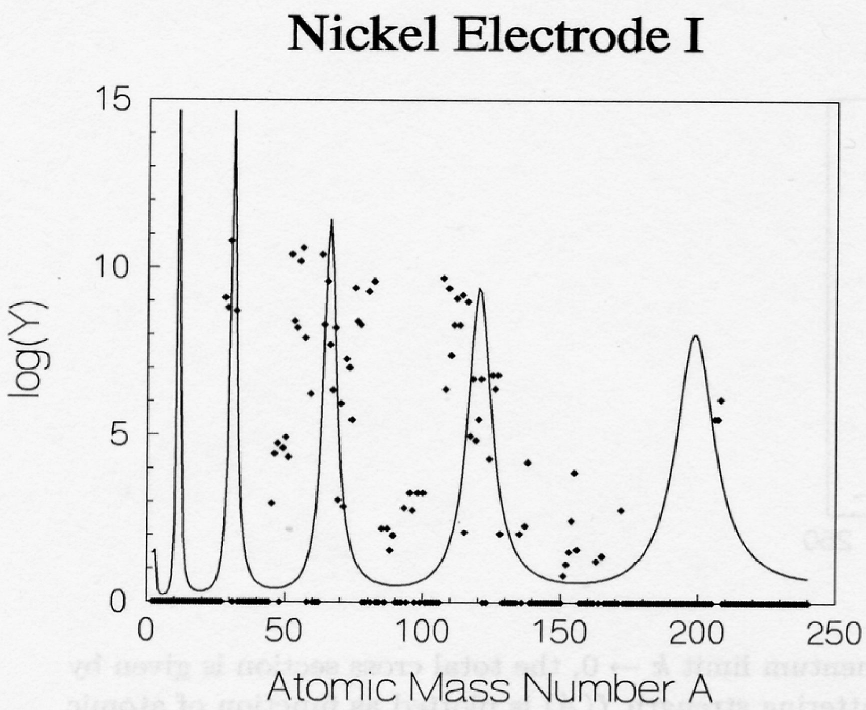


Figure 2. Shown is the experimental yield Y in parts per million Nickel electrode atoms of nuclear transmutation products during a moderately productive run. The experimental points were produced employing chemical electrolytic cells with a Nickel hydride cathode. Points exactly on the A-axis are those below detectable experimental resolution. Also plotted is a smooth theoretical curve of $8 \times f(A)$ which is proportional to the neutron absorption cross section.

Miley’s Experiments (2)

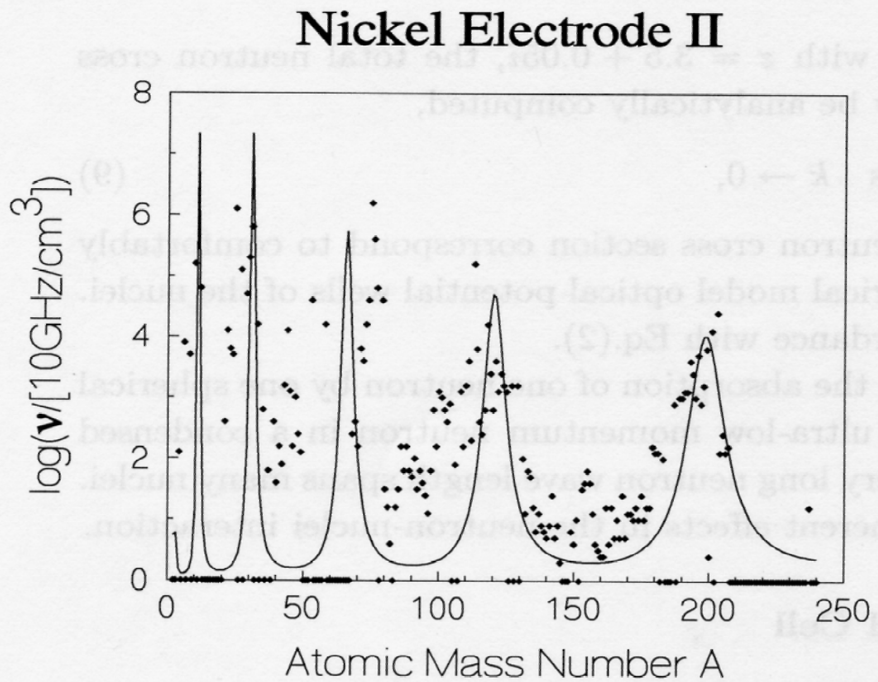


Figure 3. Shown is the experimental yield ν measured in transmutation events per second per cubic centimeter of Nickel electrode during a very productive run. The experimental points were produced employing chemical electrolytic cells with a Nickel hydride cathode. Points exactly on the A-axis are those below experimental resolution. Also plotted is a smooth theoretical curve of $4 \times f(A)$ which is proportional to the neutron absorption cross section.

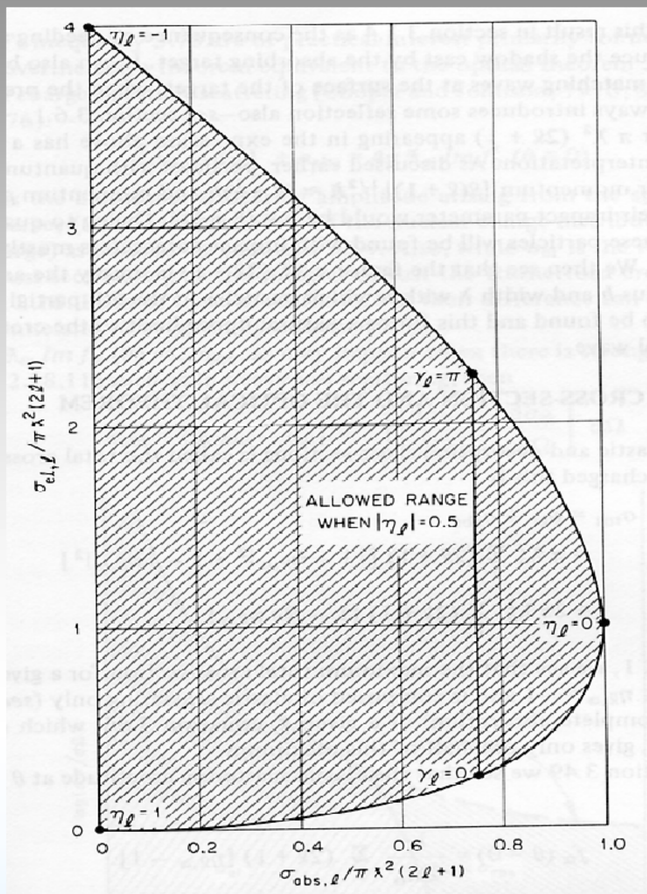
Discussion

- Theory predicts LENR reactions are possible and multi-faceted – both protons and deuterons with deuterons more efficient
- Provides explanation for lack of hard gamma radiation
- Seems to predict shape of nuclear transmutations on a nickel surface

Discussion (2)

- Does not predict the He-4 vs. evolved energy curve – example quoted is based on lithium reactions. Lithium is almost always present in LENR cells, but was not in the Iwamura experiment.
- If β_{Pd} can approach 20.6, why aren't electrons heavy enough to produce MeV neutrons
- $^{6}Li(n,\alpha)^{3}H$ reaction is 24,415 times more likely than the $^{6}Li(n,\gamma)^{7}Li$ reaction
- 16.0 MeV beta should be detectable
- Optical theorem speaks to the Total cross section but says nothing about the split between Absorption and Scattering

Possible Cross Section Variation
(G. R. Satchler)



There must always be a scattering cross section

Absorption is largest when it is equal to Scattering

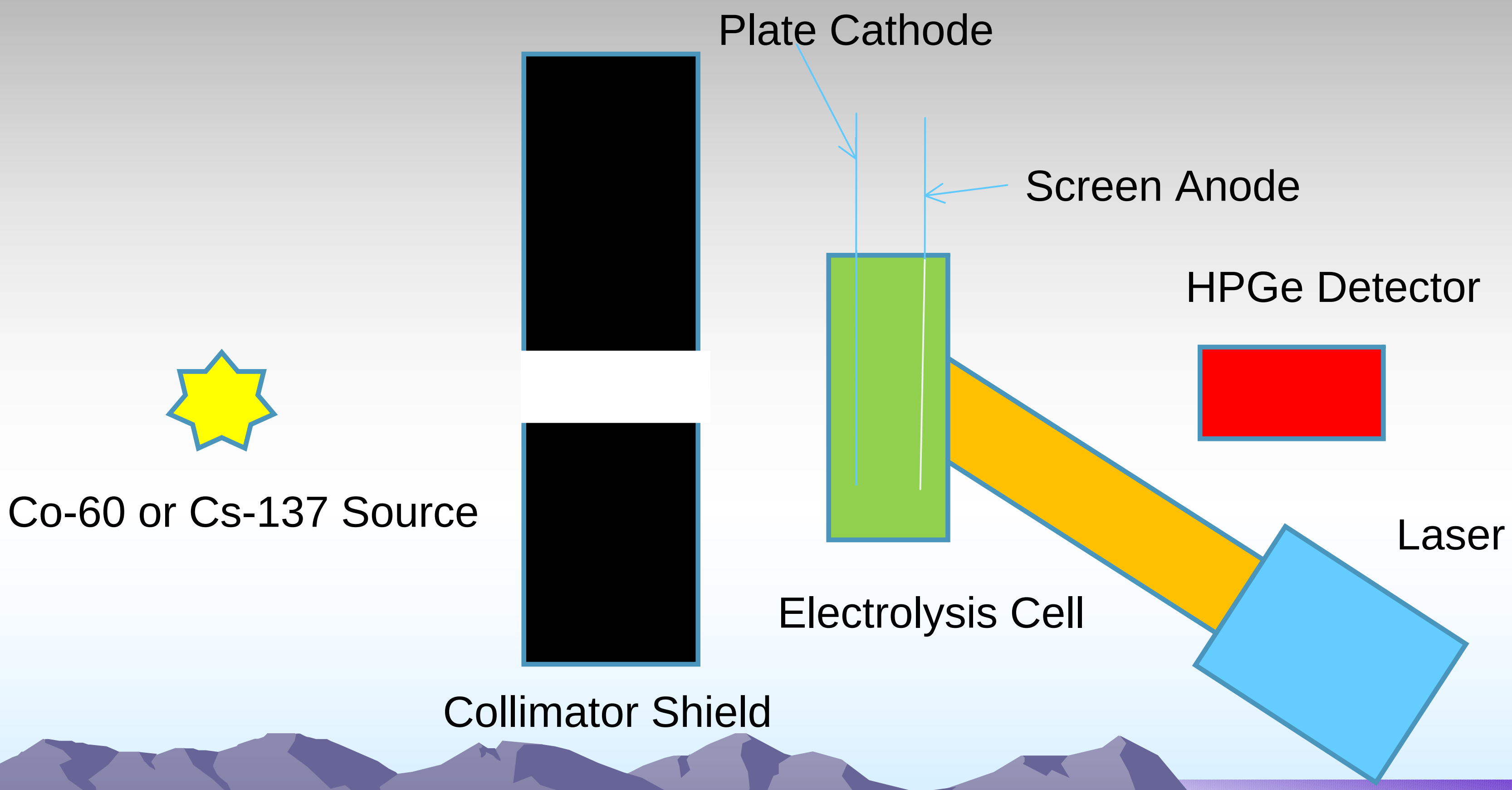
Thus there is always a finite probability that an Ultra Low Momentum neutron will scatter before it is absorbed.

A single scattering will remove it from the Ultra Low Momentum energy range and bring it to the Thermal energy range where it is detectable.

Therefore there should be a detectable population of thermal neutrons on the surface of a metallic hydride

Discussion (3)

- Absorption of hard gamma rays is detectable



Discussion (4)

- Build up and decay analysis is required before the story truly hangs together
- It would appear that the peaks in the distributions could be explained by shell closure on the proton and neutron magic numbers which may be related to a nuclear optical potential
- The truly amazing experimental result is that A> 200 can be produced from A~58 targets
- It appears that it should be possible to produce Uranium in a LENR cell