

## ***Brief Guide to Key Ideas and Examples of Experimental Evidence for the Widom-Larsen Theory (WLT) of Low Energy Nuclear Reactions (LENRs)***

### **High-level conceptual overview:**

Herein, we will discuss the non-fusion, weak interaction-driven WLT and its application to LENRs occurring in abiological condensed matter systems, abiological magnetically organized classical and dusty plasmas, and terrestrial biological systems. At the highest level of abstraction, WLT integrates many-body collective electromagnetic and condensed matter Q-M effects with modern electroweak theory under the ‘umbrella’ of the Standard Model; no “new physics” are invoked anywhere in this work.

### **Relevant publications:**

#### ***“A primer for electroweak induced low-energy nuclear reactions”***

Y. N. Srivastava, A. Widom, and L. Larsen

*Pramana - Journal of Physics* **75** (4) pp. 617 - 637 (October 2010)

Synopsis: more conceptually oriented; summary of prior WLT papers at lesser level of mathematical detail

<http://www.ias.ac.in/pramana/v75/p617/fulltext.pdf>

#### ***“Synopses of selected WLT technical papers”***

Lattice Energy LLC Technical Document, January 30, 2012 [4-pages]

Synopsis: document contains concise, more-or-less ‘plain English’ synopses of nine (9) selected technical papers concerning the Widom-Larsen theory of LENRs <http://www.slideshare.net/lewisglarsen/lattice-energy-llcsynopses-of-selected-wlt-technical-papersjan-30-2012>

In all such systems, some inputs of energy are required to trigger LENRs: input energy in certain forms is necessary to create non-equilibrium conditions that can produce ULM neutrons via collective electroweak reactions; includes (can be combined) electrical currents; ion currents; imposition of pressure gradients across interfaces; coherent laser beams; organized magnetic fields at high current densities; and so forth.

WLT explains Huizenga’s ca.1993 “three miracles”: absence of energetic neutron fluxes (neutrons are ultra low momentum and captured locally before thermalization); absence of high-energy gamma photon radiation (converted to infrared photons by heavy-mass electrons); mystery of how large Coulomb barrier to fusion of charged particles is overcome (neutrons are *neutral* particles; no Coulomb barrier to capture)

### **Abiological LENRs in condensed matter systems:**

### **Relevant publications:**

#### ***“Ultra Low Momentum Neutron Catalyzed Nuclear Reactions on Metallic Hydride Surfaces”***

A. Widom and L. Larsen

*European Physical Journal C - Particles and Fields* **46** pp. 107 (2006 – released on arXiv in May 2005)

<http://www.newenergytimes.com/v2/library/2006/2006Widom-UltraLowMomentumNeutronCatalyzed.pdf>

Key ideas: collective oscillations and quantum entanglement of many-body ‘patches’ of protons, deuterons, or tritons located on metallic surfaces or with hydrogenous atoms bonded to carbon atoms in certain structural configurations (aromatic rings, fullerenes, graphene); creation of nuclear-strength electric fields on small length-scales caused by local breakdown of Born-Oppenheimer approximation; mass-renormalization ( $e_{sp} + \text{many-body collective field energy} \rightarrow e^*$ ) of entangled surface plasmon electrons (or equivalently, delocalized  $\pi$  electrons present in certain carbon-based molecular structures) in extremely high local electric fields found in ‘patches’; once certain field-strength thresholds are surpassed, production of mostly ultra low momentum (ULM) neutrons via  $e^* + p$ ,  $e^* + d$ , or  $e^* + t$  weak



reactions can occur (also emitting electron neutrinos); almost all ULMNs are captured locally, creating complex, dynamic, neutron-catalyzed LENR nucleosynthetic networks that can produce many products.

LENR-active surface sites ('hot spots') in condensed matter are not permanent entities. In experimental systems with sufficient input energy, they will form spontaneously, 'light-up' for 10 to several hundred nanoseconds, and then suddenly 'die'. Over time, endless cycles of 'birth', nuclear energy release, and 'death' are repeated over and over again at many thousands of different, randomly scattered *nm*-to *micron*-sized locations found on a given surface. While LENRs are occurring, these tiny patches become temporary 'hot spots' - their temperatures may briefly reach 4,000 - 6,000° K or even higher. That value is roughly as hot as the surface temperature of the Sun and high enough to melt and/or even flash boil essentially all metals, including tungsten (b.p. = 5,666° C). For a brief period, a tiny dense 'ball' of very hot, highly ionized plasma is created. Such intense local heating events commonly produce numerous explosive melting features and/or 'craters' that are often observed in post-experiment surface SEM images (see Slide #69 in Lattice Technical presentation dated June 25, 2009, re Zhang & Dash, 2007).

Operation of many-body collective E-M and quantum effects enables the otherwise very distant chemical (eV) and nuclear energy (MeV) realms to 'interconnect' in micron-scale regions during brief periods of coherence to produce significant fluxes of neutrons via weak reactions in condensed matter at modest overall temperatures and pressures. Thus, cores of stars, supernovae, fission reactors (manmade or natural), and detonating nuclear weapons are not the only environments in Nature or man's laboratories where neutron-catalyzed nucleosynthetic networks may occur, producing stable elements, isotopic products, and macroscopic thermal effects that, when significant, can be measured via calorimetry.

**"Absorption of Nuclear Gamma Radiation by Heavy Electrons on Metallic Hydride Surfaces"**

A. Widom and L. Larsen (Sept 2005)

[http://arxiv.org/PS\\_cache/cond-mat/pdf/0509/0509269v1.pdf](http://arxiv.org/PS_cache/cond-mat/pdf/0509/0509269v1.pdf)

**"Apparatus and Method for Absorption of Incident Gamma Radiation and its Conversion to Outgoing Radiation at Less Penetrating, Lower Energies and Frequencies"**

Inventors: L. Larsen and A. Widom

US Patent #7,893,414 filed in 2005 and issued by the USPTO on February 22, 2011

Comment: invention based on physics and principles published in September 2005 Cornell arXiv preprint

<http://www.slideshare.net/lewisglarsen/us-patent-7893414-b2>

**"Nuclear Abundances in Metallic Hydride Electrodes of Electrolytic Chemical Cells"**

A. Widom and L. Larsen (Feb 2006)

Comment: Miley & Mizuno's odd 5-peak mass spectrum is unique fingerprint' of ULM neutron captures

[http://arxiv.org/PS\\_cache/cond-mat/pdf/0602/0602472v1.pdf](http://arxiv.org/PS_cache/cond-mat/pdf/0602/0602472v1.pdf)

Comment: discussed on Slides # 14 - 16 in <http://www.slideshare.net/lewisglarsen/lattice-energy-llc-changes-in-solar-neutrino-fluxes-alter-nuclear-beta-decay-rates-on-earth-june-3-2011>

**"Theoretical Standard Model Rates of Proton to Neutron Conversions near Metallic Hydride Surfaces"** A. Widom and L. Larsen (Sep 2007)

Comment: to be believable, key question that *any* weak-interaction based theory of LENRs must answer is exactly why and how  $e + p$  or  $e + d$  weak reactions can potentially occur at high rates in condensed matter systems under modest conditions of temperature and pressure. Authors demonstrate that substantial ULM neutron production rates via such electroweak reactions are theoretically possible under such conditions; calculated results for such rates in a model electrolytic chemical cell (on the order of  $10^{12}$  to  $10^{14}$  neutrons  $\text{cm}^2/\text{second}$ ) are in good agreement with the best available published experimental data.

[http://arxiv.org/PS\\_cache/nucl-th/pdf/0608/0608059v2.pdf](http://arxiv.org/PS_cache/nucl-th/pdf/0608/0608059v2.pdf)

**Case: Electrolytic chemical cells (aqueous Pons & Fleischmann-type systems; metallic electrodes)**

Comment: experimental data of Mizuno re ca. 2006 'explosion' event analyzed on Slides # 56 - 59 in <http://www.slideshare.net/lewisglarsen/lattice-energy-llc-technical-overview-june-25-2009>; transmutation data of Iwamura *et al.* with *gas-phase* LENR systems is also explained on Slides # 44 - 45 and 60 - 67.



**Case: high-current electrical arcs using pure carbon electrodes bathed in H<sub>2</sub>O during arcing**

Comment: data from experiments conducted at Texas A&M University and Bhabha Atomic Research Center (India) published in *Fusion Technology* (1994) discussed in Slides # 38 - 56 in <http://www.slideshare.net/lewisglarsen/lattice-energy-llctechnical-overviewcarbon-seed-lenr-networkssept-3-2009>

**Case: Resonant electromagnetic cavities (no-electric-input-current P/T reactors with metallic walls)**

Comment: innovative and important gas-phase Ni-H experiments by Italian researchers are explained in <http://www.slideshare.net/lewisglarsen/lattice-energy-llcnickelseed-lenr-networksapril-20-2011>

**Case: Accumulation of strain energy in chemical bonds and fracturing of rocks in planetary crusts**

**"Neutron Production from the Fracture of Piezoelectric Rocks"**

A. Widom, J. Swain, and Y. N. Srivastava (v2 uploaded in February 2012)

Comment: theoretical explanation is provided for the experimental evidence that fracturing piezoelectric rocks produces neutrons; provides mechanism for low rates of LENR nucleosynthesis in earth's crust <http://arxiv.org/pdf/1109.4911v2.pdf>

**Abiological LENRs in magnetically organized classical and 'dusty' plasmas:**

**Relevant publications:**

**"Energetic Electrons and Nuclear Transmutations in Exploding Wires"**

A. Widom, Y. N. Srivastava, and L. Larsen (Sept 2007)  
[http://arxiv.org/PS\\_cache/arxiv/pdf/0709/0709.1222v1.pdf](http://arxiv.org/PS_cache/arxiv/pdf/0709/0709.1222v1.pdf)

**"High Energy Particles in the Solar Corona"**

A. Widom, Y. N. Srivastava, and L. Larsen (April 2008)  
[http://arxiv.org/PS\\_cache/arxiv/pdf/0804/0804.2647v1.pdf](http://arxiv.org/PS_cache/arxiv/pdf/0804/0804.2647v1.pdf)

**Key ideas:** many-body collective electromagnetic features of WLT are further extended to cover cases of LENRs that can occur in exploding wires, prosaic electrical arcs, natural atmospheric lightning, and magnetic flux tubes on stars; all being systems that comprise vastly lower density, gaseous ionized plasmas. Conceptually, such systems are treated as magnetically organized, plasma-filled structures having tubular geometries. The paper explains exactly how longer range *many-body collective magnetic field effects* can induce substantial production of neutrons via weak  $e + p$  reactions and accelerate charged particles (e.g., protons) present in such organized structures, both in the laboratory and in Nature. In such magnetically dominated LENR regimes, energy required to drive weak interaction neutron production and particle acceleration is transferred and delivered to embedded charged particles (e.g., electrons, protons) through much longer-range *collective many-body magnetic field effects*. Thus, the physics of this regime differs somewhat from WLT physics that applies to micron-scale LENR-active regions found on condensed matter surfaces wherein nuclear-strength *localized collective electric fields* in conjunction with Q-M entanglement and surface plasmon effects provide the energy required to drive WLT ULM neutron production via electroweak interactions.

An implication of this thinking is that significant amounts of nucleosynthesis and high-energy particle acceleration/production can occur in flux tubes and explosive flares well outside the boundaries of a star's very dense, super-hot core. This not-so-new idea first voiced by Fowler, Burbidge (2), and Hoyle (*Astrophysical Jour.*, 1965) is contrary to presently widespread beliefs that fusion processes occurring inside stellar cores are the only nuclear processes of significance going on in the sun and other stars.

Comments: all of this is discussed in detail, including experimental evidence published in peer-reviewed journals that supports the idea of our many-body collective magnetic mechanism, in the 88-slide <http://www.slideshare.net/lewisglarsen/lattice-energy-llc-changes-in-solar-neutrino-fluxes-alter-nuclear-betadecay-rates-on-earthjune-3-2011>; supportive data of Jenkins & Fischbach (2009) is also discussed.



## **LENRs in terrestrial biological systems:**

### **Relevant publications:**

#### ***“Some bacteria appear capable of altering isotopic ratios of Uranium --- Is it the result of prosaic chemical fractionation processes and/or LENRs?”***

Lattice Energy LLC Technical Document, December 7, 2010 [50-pages]

Synopsis: provides description of theoretical W-L LENR Actinide nucleosynthetic network and selected examples of published mainstream, peer-reviewed experimental data which report anomalous isotopic shifts clearly associated with *in vivo* metabolic activities of bacteria --- some or all of the hypothesized network pathways are potentially present in soils, ocean sediments, dusty chemical explosions, volcanic eruptions, and extraterrestrial impact events. <http://www.slideshare.net/lewisglarsen/bacteria-lenrsand-isotopic-shifts-in-uraniumlarsenlattice-energy-dec-7-2010-6177275>

#### ***“Nuclear Transmutation of Stable and Radioactive Isotopes in Biological Systems”***

V. Vysotskii and A. Kornilova ISBN: 978-81-8274-430-1 Hardcover 192 pages Pentagon Press (2010)

Comments: updated version of the out-of-print 2003 book by Mir Press (Moscow – Mir is now defunct)

What types of nanoscale macromolecular biological structures might support the high local electric fields needed to create ULM neutrons from protons via the WLT mechanism? It would appear that interior walls of enzymes' active sites and various types of membrane surfaces or interfaces separating charges are likely locations where biological LENRs might be occurring. Well-respected researchers (enzyme chemists) have already measured static E-fields of  $\sim 10^9$  V/m in such active sites; so fast-transient dynamic increases in local field strength caused by rapid structural conformation changes involving rapidly moving charged groups could very likely achieve the  $> \sim 2 \times 10^{11}$  V/m threshold for the number of attoseconds required to trigger ULM neutron production. In 2011, scientists at the Indira Gandhi Centre for Atomic Research (India) may have experimentally confirmed Vysotskii & Kornilova's early seminal experiments ca. 2003 in which they claimed to have observed *in vivo* bacterial (nuclear) transmutation of elemental Manganese (Mn) into Iron (Fe); a paper has presumably been submitted by R. George *et al.*

## **Final remarks re commercialization --- vast new opportunities in basic and applied R&D:**

LENRS are potentially a truly 'green' nuclear energy technology: they do not emit large fluxes of dangerous energetic neutrons, deadly MeV gamma radiation, nor do they produce biologically significant amounts of hazardous long-lived radioactive wastes. Likely absence of any shielding or containment issues opens up the possibility of eventually developing revolutionary portable battery-like nuclear power sources that have orders-of-magnitude improvement in cost, energy density, and longevity compared to competing chemically-powered batteries, fuel cells, and fossil-fueled microgenerators. Commercialization efforts could potentially provide a vast array of new opportunities for scientists working in basic and applied LENR research. WLT suggests that collective many-body electroweak processes may be widespread in Nature, hidden in plain sight 'til now. Nucleosynthesis may thus be occurring at varied rates in more places in the Universe than anyone ever imagined. This possibility opens-up huge new vistas for future research and promises further insights into the history of galactic and planetary chemical evolution.

## **Other selected Lattice-related information resources re experimental support for WLT:**

### **Case: Resonant electromagnetic cavities (no-electric-input-current P/T reactors with metallic walls)**

Comment: SRI's Les Case replication experiment (McKubre, 1999) is analyzed on Slides # 19 - 37 in

<http://www.slideshare.net/lewisglarsen/lattice-energy-llctechnical-overviewcarbon-seed-lenr-networkssept-3-2009>; Slide #34, WLT predicts MeV/He-4 value much closer than D-D fusion hypothesis

Comment: Mizuno's innovative 2008 experiments with organic aromatic Phenanthrene are analyzed in

<http://www.slideshare.net/lewisglarsen/lattice-energy-llctechnical-overviewpahs-and-lenrsnov-25-2009>

Comment: transmutation products potentially observed in exhaust emissions from catalytic converters

<http://www.slideshare.net/lewisglarsen/lattice-energy-llc-len-rs-in-catalytic-convertersjune-25-2010>