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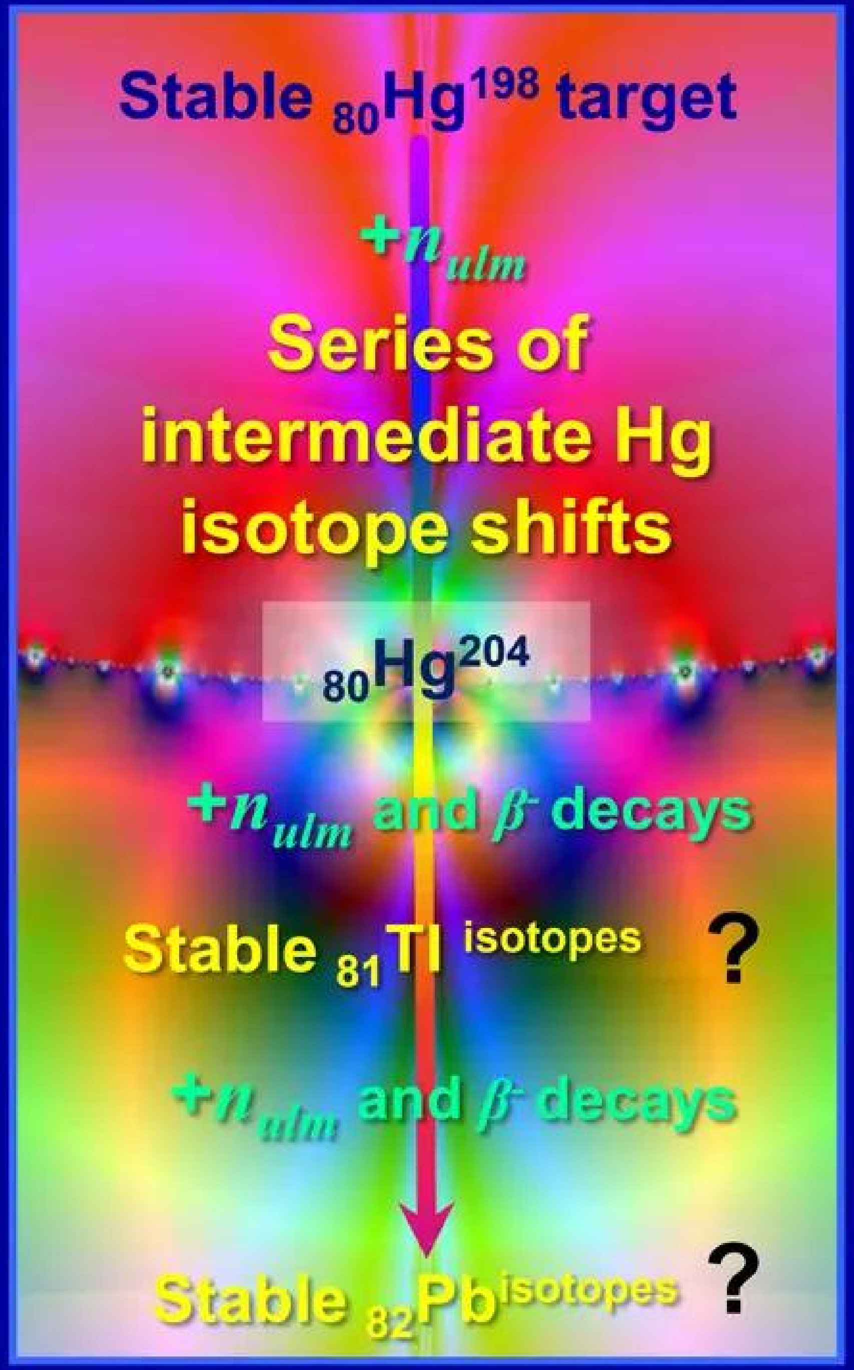
Low energy neutron reactions (LENRs)

Neutron-catalyzed LENR transmutations can alter Mercury isotopes

Mead *et al*. reported inexplicable Hg isotope shifts in compact fluorescent lights

LENRs may be occurring at very low rates during everyday operation of CFLs

Widom-Larsen LENR network



Neutron-catalyzed transmutations

Technical Comments

Lewis Larsen

President and CEO
Lattice Energy LLC
March 7, 2013

> "Facts do not cease to exist because they are ignored."
>
> Aldous Huxley in
> "Proper Studies" 1927

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Revised August 28, 2014

Compact home fluorescent light

Neutron-catalyzed transmutations?

LENRs don't produce hard radiation or long-lived wastes

Thus can be hidden in plain sight and occur in many surprising places

Subtle isotopic traces of LENRs can readily be observed with mass spectroscopy

Main points in this presentation

- ✓ Cite and discuss outstanding new experimental paper by Mead *et al*. (*Environmental Science and Technology*, Feb. 2013) in which they report measurements of anomalous shifts in Mercury isotopes found in household compact fluorescent lights (CFLs); according to the paper's authors, a portion of these observed shifts are simply not explainable with well-known MDF or MIF mechanisms for prosaic chemical fractionation

- ✓ Examine strong possibility that some indeterminate percentage of isotopic shift anomalies present in Mead *et al.*'s new data could potentially have been caused by low energy neutron reactions (LENRs) occurring at extremely low rates somewhere inside CF lights during normal operation; this would be an unexpected, surprising discovery

- ✓ Discuss additional types of measurements that experimentalists could make on such CFLs (SIMS, solid-state NMR, etc.) to unambiguously determine: (1) whether LENRs are occurring therein; (2) if so, at exactly what locations inside the lights; (3) at what reaction rates; and (4) what percentage of observed shifts in Mercury isotopes might reasonably be attributed to LENR transmutations vs. prosaic chemical fractionation processes?

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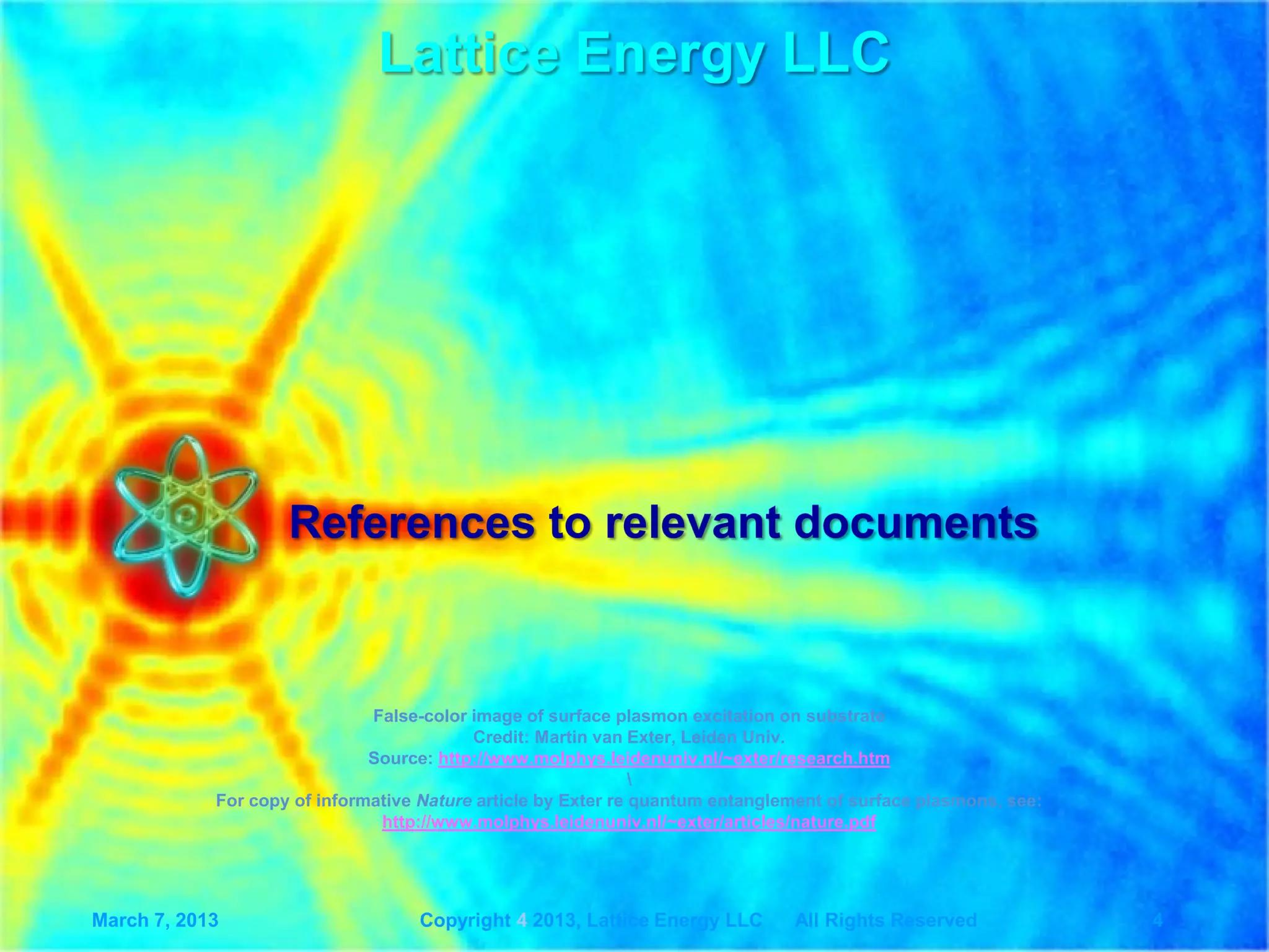
Contents



References to relevant documents

False-color image of surface plasmon excitation on substrate
Credit: Martin van Exter, Leiden Univ.
Source: http://www.molphys.leidenuniv.nl/~exter/research.htm
\
For copy of informative *Nature* article by Exter re quantum entanglement of surface plasmons, see:
http://www.molphys.leidenuniv.nl/~exter/articles/nature.pdf

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References to relevant documents

Reported inexplicable shifts of Mercury isotopes in consumer lamps

"Unique Hg stable isotope signatures of compact fluorescent lamp-sourced Hg"
C. Mead, J. Lyons, T. Johnson, and D. Anbar
Environmental Science & Technology **DOI: 10.1021/es303940p (web: February 4, 2013)**
http://pubs.acs.org/doi/abs/10.1021/es303940p [e-cost is US$35.00 for non-subscribers]

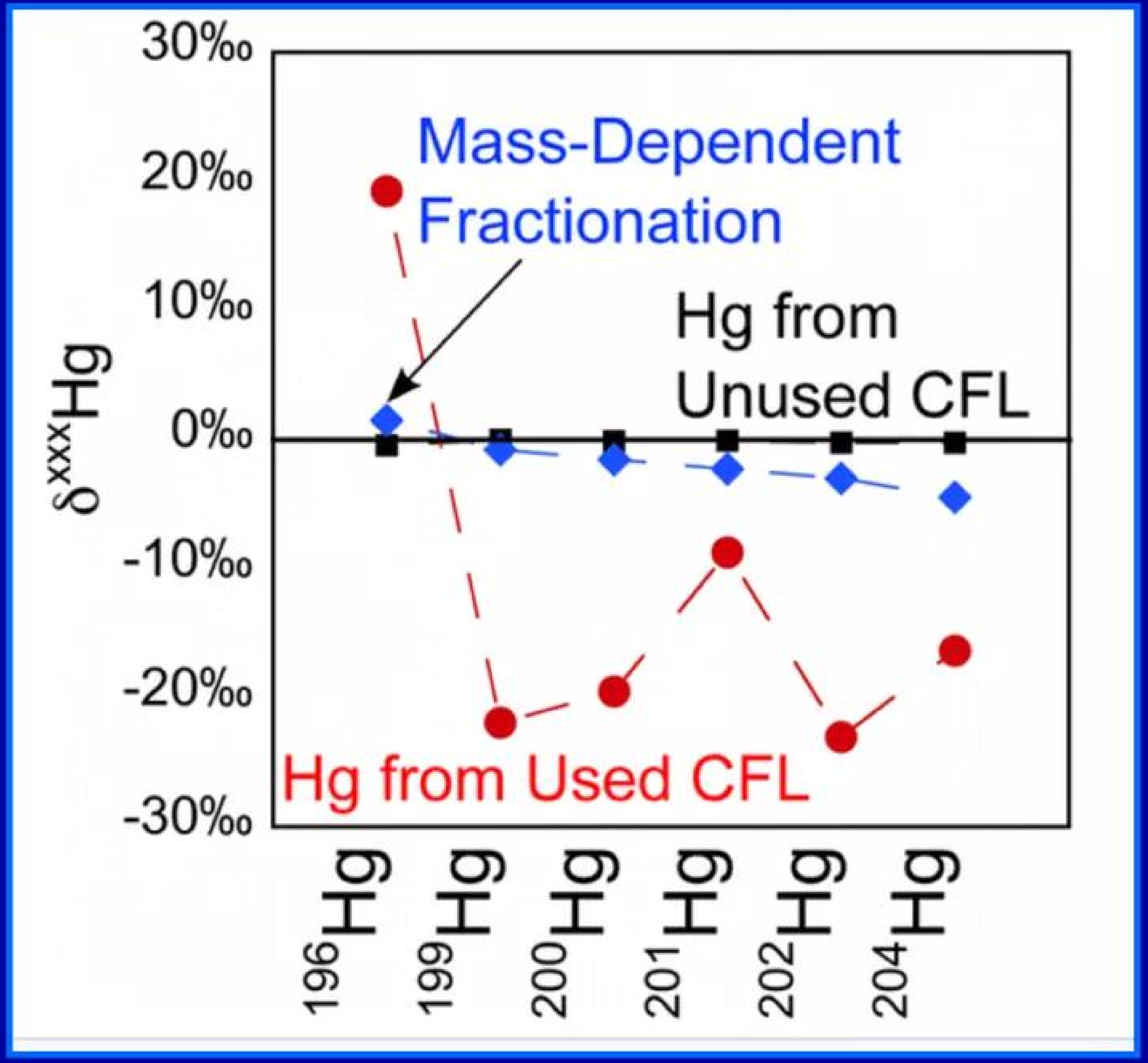
Quoting abstract directly:

"The recent widespread adoption of compact fluorescent lamps (CFL) has increased their importance as a source of environmental Hg. Stable isotope analysis can identify the sources of environmental Hg, but the isotopic composition of Hg from CFL is not yet known. Results from analyses of CFL with a range of hours of use show that the Hg they contain is isotopically fractionated in a unique pattern during normal CFL operation. This fractionation is large by comparison to other known fractionating processes for Hg and has a distinctive, mass-independent signature, such that CFL Hg could be uniquely identified from other sources. The fractionation process described here may also explain anomalous fractionation of Hg isotopes in precipitation."

Direct quotes selected from body of paper:

"Trapped Hg of used CFL show unusually large isotopic fractionation, the pattern of which is entirely different from that which has been observed in previous Hg isotope research aside from intentional isotope enrichment. Most notably, there is no straightforward relationship between extent of fractionation and isotope mass. Thus, while previous studies of MIF of Hg only observed large deviations from mass-dependence in odd mass isotopes, our results clearly show MIF across multiple even mass and odd mass isotopes."

Fig. shows large deviations from MDF and unused samples



Source: webpage at
http://pubs.acs.org/doi/abs/10.1021/es303940p

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References to relevant documents

LENR physics and transmutations now understood and published

"Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces"
European Physical Journal C - Particles and Fields 46 pp. 107 - 112 (2006)
A. Widom and L. Larsen
http://www.slideshare.net/lewisglarsen/widom-and-larsen-ulm-neutron-catalyzed-lenrs-on-metallic-hydride-surfacesepjc-march-2006

"Absorption of nuclear gamma radiation by heavy electrons on metallic hydride surfaces"
http://arxiv.org/PS_cache/cond-mat/pdf/0509/0509269v1.pdf (Sept 2005) Widom and Larsen

"Nuclear abundances in metallic hydride electrodes of electrolytic chemical cells"
http://arxiv.org/PS_cache/cond-mat/pdf/0602/0602472v1.pdf (Feb 2006) Widom and Larsen

"Theoretical Standard Model rates of proton to neutron conversions near metallic hydride surfaces"
http://arxiv.org/PS_cache/nucl-th/pdf/0608/0608059v2.pdf (v2. Sep 2007) Widom and Larsen

"Energetic electrons and nuclear transmutations in exploding wires"
http://arxiv.org/PS_cache/arxiv/pdf/0709/0709.1222v1.pdf (Sept 2007) Widom, Srivastava, and Larsen

"Errors in the quantum electrodynamic mass analysis of Hagelstein and Chaudhary"
http://arxiv.org/PS_cache/arxiv/pdf/0802/0802.0466v2.pdf (Feb 2008) Widom, Srivastava, and Larsen

"High energy particles in the solar corona"
http://arxiv.org/PS_cache/arxiv/pdf/0804/0804.2647v1.pdf (April 2008) Widom, Srivastava, and Larsen

"A primer for electro-weak induced low energy nuclear reactions"
Pramana - Journal of Physics 75 pp. 617 - 637 (2010)
Y. Srivastava, A. Widom, and L. Larsen
http://www.ias.ac.in/pramana/v75/p617/fulltext.pdf

"Erroneous wave functions of Ciuchi et al. for collective modes in neutron production on metallic hydride cathodes" http://arxiv.org/pdf/1210.5212v1.pdf (v1 Oct. 17, 2012) Widom, Srivastava, and Larsen

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References to relevant documents

Lattice presentations available on company's SlideShare web presence

- ✓ **"LENRs in catalytic converters: are green LENRs occurring in common devices?"**
  L. Larsen, June 25, 2010 [76 PowerPoint slides]
  http://www.slideshare.net/lewisglarsen/lattice-energy-llc-len-rs-in-catalytic-convertersjune-25-2010
  Note: discuss mass spectroscopy data indicating LENRs could be occurring at very low rates therein

- ✓ **"Polycyclic aromatic hydrocarbons (PAHs) and LENRs"**
  L. Larsen, November 25, 2009 [61 PowerPoint slides]
  http://www.slideshare.net/lewisglarsen/lattice-energy-llctechnical-overviewpahs-and-lenrsnov-25-2009
  Note: shows how LENRs can be triggered on aromatic Carbon rings with just temperature, pressure, time

- ✓ **"Neutron-catalyzed LENR transmutations produce Gold from Tungsten; Mitsubishi Heavy Industries presents new data at Winter ANS meeting"**
  L. Larsen, December 7, 2012 [29 PowerPoint slides]
  http://www.slideshare.net/lewisglarsen/lattice-energy-llc-lenr-transmutation-networks-can-produce-golddec-7-2012
  Note: Mitsubishi reported experimental data; confirms W-L LENR network pathway: W → Re → Os → Ir → Pt → Au

- ✓ **"Surface plasmons on Graphene are confirmed"**
  L. Larsen, July 6, 2012 [64 PowerPoint slides]
  http://www.slideshare.net/lewisglarsen/lattice-energy-llclenrs-on-hydrogenated-fullerenes-and-graphenejuly-6-2012
  Note: discuss confirmation of surface plasmons on Graphene; LENRs in electric arcs w. Carbon electrodes in H_2O

- ✓ **"Index to key concepts and documents"**
  L. Larsen, Version #19, updated through August 19, 2014 [119 PowerPoint slides]
  http://www.slideshare.net/lewisglarsen/lattice-energy-llc-index-to-documents-re-widomlarsen-theory-of-lenrsmay-28-2013
  Note: provides title, description, and URL for many online documents about Widom-Larsen theory, LENRs, and Lattice

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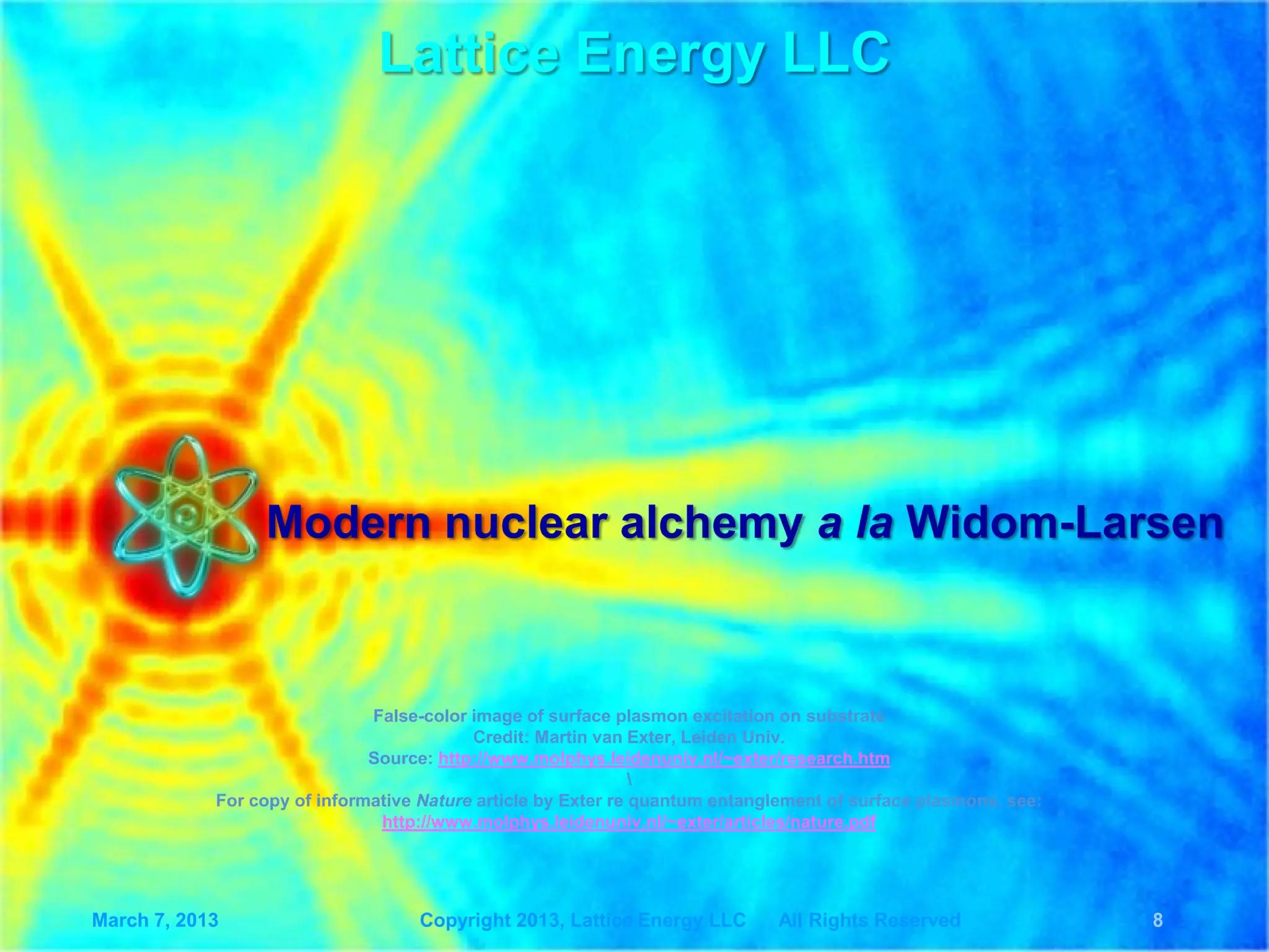

Modern nuclear alchemy *a la* Widom-Larsen

False-color image of surface plasmon excitation on substrate
Credit: Martin van Exter, Leiden Univ.
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For copy of informative *Nature* article by Exter re quantum entanglement of surface plasmons, see:
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Modern nuclear alchemy *al la* Widom-Larsen

Kant comments on search for truth in the advancement of science

"We have now not only traversed the region of the pure understanding and carefully surveyed every part of it, but we have also measured it, and assigned to everything therein its proper place. But this land is an island, and enclosed by Nature herself within unchangeable limits. It is the land of truth (an attractive word), surrounded by a wide and stormy ocean, the region of illusion, where many a fog-bank, many an iceberg, seems to the mariner, on his voyage of discovery, a new country, and, while constantly deluding him with vain hopes, engages him in dangerous adventures, from which he never can desist, and which yet he never can bring to a termination. But before venturing upon this sea, in order to explore it in its whole extent, and to arrive at a certainty whether anything is to be discovered there, it will not be without advantage if we cast our eyes upon the chart of the land that we are about to leave, and to ask ourselves, firstly, whether we cannot rest perfectly contented with what it contains, or whether we must not of necessity be contented with it, if we can find nowhere else a solid foundation to build upon; and, secondly, by what title we possess this land itself, and how we hold it secure against all hostile claims?"

Immanuel Kant, "The Critique of Pure Reason" (1781)

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Modern nuclear alchemy *al la* Widom-Larsen

Nuclear and chemical energy realms can interconnect in small regions

"Oh, East is East, and West is West, and never the twain shall meet."[1.]

Since the inception of modern nuclear science in ~1940s, it has been widely believed that the only nuclear processes suitable for commercial power generation were strong interaction fission or fusion; it was also thought that nuclear transmutation reactions could only happen in certain environments, e.g., fission reactors, nuclear weapons, or stars. Pons & Fleischmann's 1989 discovery of seemingly nuclear processes operating inside what would otherwise be ordinary D_2O electrolytic chemical cells challenged long-established conceptual paradigms about nuclear physics. Initially, P&F rashly speculated that their observed radiation-free "excess heat" resulted from some sort of a D+D "cold fusion" process. That totally erroneous theoretical idea, coupled with then-irreproducible experimental results, resulted in deep skepticism about LENRs by mainstream scientists that has persisted to the present. Starting with release of our first arXiv preprint in 2005, the Widom-Larsen theory of LENRs has shown, using known physics, how energetic nuclear reactions can occur in ordinary chemical cells. Per W-L, key aspects of LENRs involve weak interactions that can occur in a variety of different environments under relatively mild physical conditions. Our theory posits that in condensed matter systems, many-body collective quantum effects allow otherwise disparate chemical and nuclear energy realms to briefly interconnect in special nm- to micron-scale regions on surfaces.

1. Rudyard Kipling, "The Battle of East and West" (1889)

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Modern nuclear alchemy *al la* Widom-Larsen

Uncharged neutrons play a crucial role in modern transmutation

1941: US nuclear physicists realized an age-old dream of the ancient alchemists

"The neutron plays a pivotal role in manmade transmutations. In the words of Bronowski, 'At twilight on the sixth day of Creation, so say the Hebrew commentators to the Old Testament, God made for man a number of tools that gave him also the gift of creation. If the commentators were alive today, they would write, 'God made the neutron.' Is it far-fetched to consider the neutron to be the Stone of the Philosophers (and atom smashers to be athanors – the furnaces of the Philosophic Egg)? Frankly, yes. But, in 1941, fast neutrons were used to transmute mercury into a tiny quantity of gold[1.]. Was the age old dream realized? Would a modern day version of the Roman Emperor Diocletian have to burn all the notebooks and journal articles and destroy the atom smashers in order to protect the world's currency? Well, probably not. It is likely that an ounce of such gold would cost more than the net worth of the planet. Also, the gold so obtained is radioactive and lives for only a few days at most. But, we are not always logical when it comes to gold. In the words of Black Elk, a holy man of the Oglala Lakota-Sioux on the Pine Ridge Reservation in South Dakota, 'Our people knew there was yellow metal in little chunks up there, but they did not bother with it, because it was not good for anything'."

[1.] **Sherr *et al.*, *The Physical Review* 60 pp. 473 - 479 (1941)**

Arthur Greenberg, "From Alchemy to Chemistry in Picture and Story" pp. 571 2007

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Modern nuclear alchemy *al la* Widom-Larsen

Ultra low energy neutrons play key role in LENR transmutations

Widom-Larsen breakthrough theory based on well-accepted nuclear science

"Alchemy, derived from the Arabic word 'al-kimia' is both a philosophy and an ancient practice focused on the attempt to change base metals into gold, investigating the preparation of the 'elixir of longevity', and achieving ultimate wisdom, involving the improvement of the alchemist as well as the making of several substances described as possessing unusual properties. The practical aspect of alchemy generated the basics of modern inorganic chemistry, namely concerning procedures, equipment and the identification and use of many current substances. Alchemy has been practiced in ancient Egypt, Mesopotamia (modern Iraq), India (modern Indian subcontinent), Persia (modern Iran), China, Japan, Korea, the classical Greco-Roman world, the medieval Islamic world, and then medieval Europe up to the 20th century, in a complex network of schools and philosophical systems spanning at least 2,500 years."

Source for above quote: Wikipedia article as of July 7, 2010

According to the WLT, LENRs and chemistry intersect on nm - μ length-scales in condensed matter systems under comparatively 'mild' conditions compared to interiors of stars, nuclear weapons, and fuel rods of operating fission reactors. Production of gold from lower-Z elements such as Tungsten (W) is not just some alchemist's fevered delusion. It is an understandable result of ULM neutron-captures on W and subsequent beta decays, both of which are presently well-accepted in mainstream nuclear science

US Atomic Energy Commission (AEC) produced Gold

Dreams of the ancient alchemists come true in the chain-reacting pile at Oak Ridge, Tenn.

U. S. Alchemists Make Gold

Applying atomic magic to aid medicine and research, radiochemists duplicate nature's elements and create new ones.

By Alden P. Armagnac

Drawings by Ray Pioch

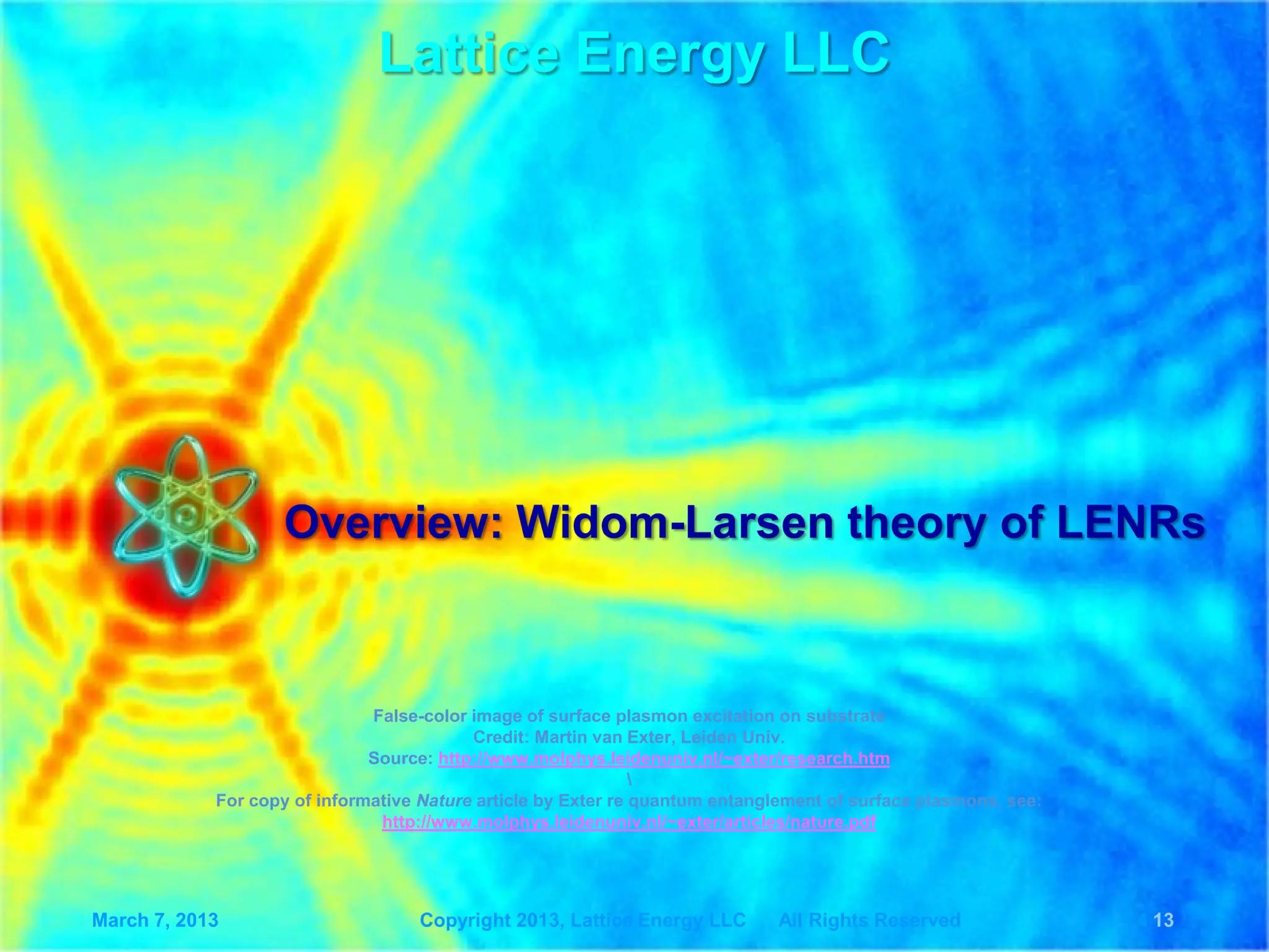
AT Oak Ridge, Tenn., the United States Atomic Energy Commission has gone into the business of manufacturing synthetic gold. The atomic pile is the Philosopher's Stone, long sought by the ancient alchemists, which has the 24-carat touch.

Most curious part of the new enterprise is the odd behavior of the man-made gold. Though locked in the strongest vault, most of it would disappear within a week's time. Strange to say, this extraordinary way of acting actually enhances the gold's value. What makes it so desirable is the fact that it is radioactive. Hence the ray-emitting "radiogold" offers medical men a priceless tool for treating such maladies as leukemia, lymphoma and Hodgkin's disease. At one institution alone, Vanderbilt University Medical School in Nashville, Tenn., it has benefited 61 patients in the first year of use.

For therapy and for "tagging" chemicals used in research, Oak Ridge's alchemists—or "radiochemists," as they call themselves—produce scores of artificially radioactive elements like radiogold. But they are by no means limited to "freak" products that have no counterpart in nature.

MARCH 1948 159

"Popular Science" magazine, March 1948



Overview: Widom-Larsen theory of LENRs

False-color image of surface plasmon excitation on substrate
Credit: Martin van Exter, Leiden Univ.
Source: http://www.molphys.leidenuniv.nl/~exter/research.htm
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For copy of informative *Nature* article by Exter re quantum entanglement of surface plasmons, see:
http://www.molphys.leidenuniv.nl/~exter/articles/nature.pdf

Overview: Widom-Larsen theory of LENRs

In condensed matter systems, Steps 1. through 4. occur in nm- to μ-sized patch regions on surfaces; these are called LENR-active sites

Steps 1. thru 3. are very fast: can complete in 2 to 300 nanoseconds

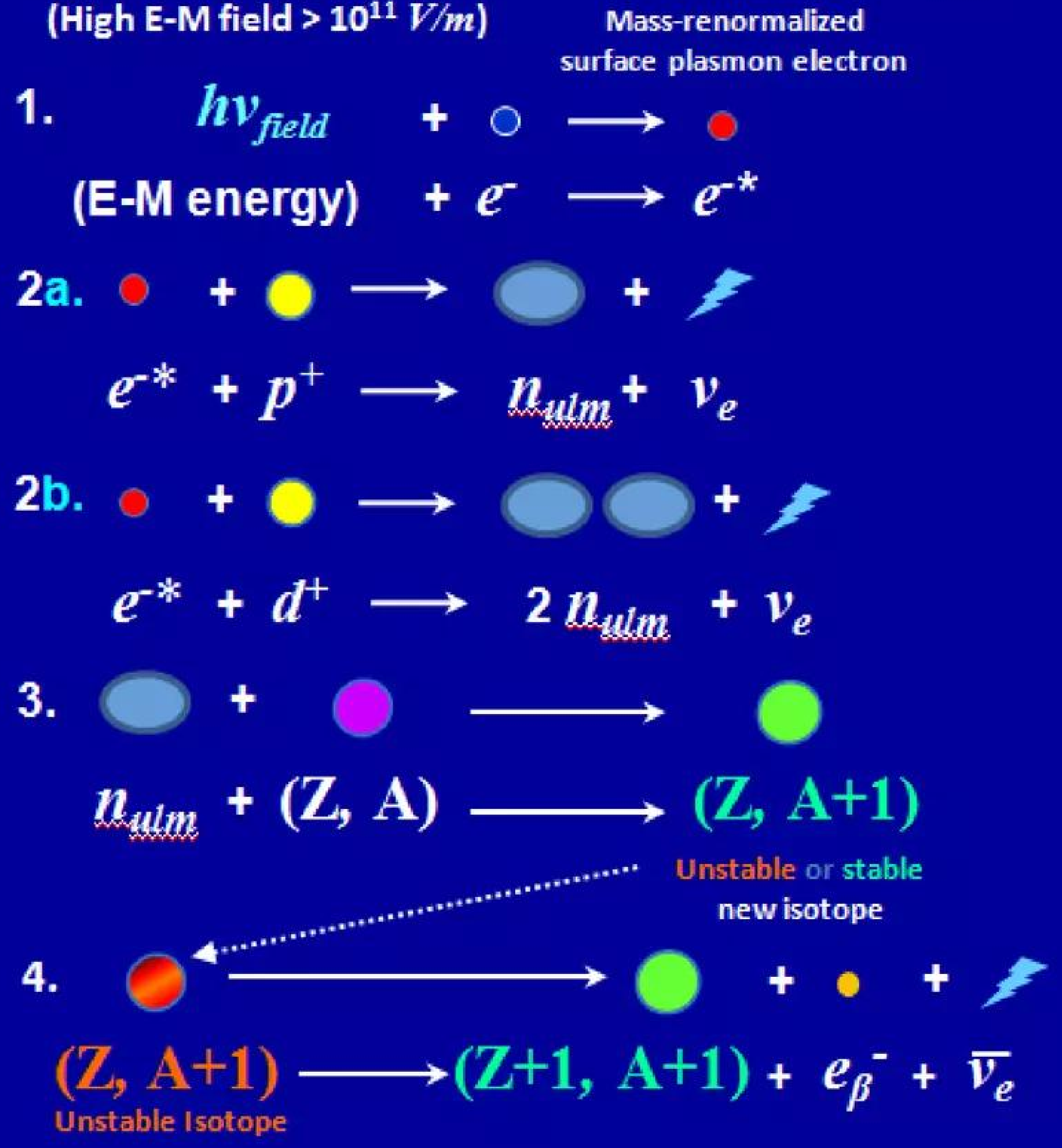
1. Electromagnetic (E-M) radiation on a metallic hydride surface increases mass of surface plasmon (SP) electrons
2. Heavy-mass surface plasmon electrons react directly with (a) surface protons (p^+) or (b) deuterons (d^+) to produce ultra low momentum (ULM) neutrons (n_{ulm} or 2 n_{ulm}, respectively) and an electron neutrino (ν_e)
3. Ultra low momentum neutrons (n_{ulm}) are captured by nearby atomic nuclei (Z, A) representing some element with charge (Z) and atomic mass (A). ULM neutron absorption produces a heavier-mass isotope (Z, A+1) via transmutation. This new isotope (Z, A+1) may itself be a stable or unstable, which will perforce eventually decay
4. Many unstable isotopes β^- decay, producing: transmuted element with increased charge (Z+1), ~same mass (A+1) as parent nucleus; β^- particle (e_β^-); and an antineutrino ν_e

Ultra low momentum neutrons are almost all captured locally (very few have time to thermalize and be detected); any gammas produced get converted directly to infrared photons (heat) by heavy electrons

Note: colored shapes are associated with the diagram on next Slide

No strong interaction fusion or heavy element fission occurring below; weak interaction $e + p$ or $e + d$

(High E-M field > 10^{11} V/m)



1. $h\nu_{field} + ○ \longrightarrow ●$

(E-M energy) $+ e^- \longrightarrow e^{-*}$

2a. $e^{-*} + p^+ \longrightarrow n_{ulm} + \nu_e$

2b. $e^{-*} + d^+ \longrightarrow 2\,n_{ulm} + \nu_e$

3. $n_{ulm} + (Z, A) \longrightarrow (Z, A+1)$

Unstable or stable new isotope

4. $(Z, A+1) \longrightarrow (Z+1,\ A+1) + e_\beta^- + \overline{\nu}_e$

Unstable Isotope

Weak interaction β^- decays (shown just above), direct gamma conversion to infrared photons (not shown), and α decays (not shown) produce most of the excess heat that is calorimetrically observed in LENR systems

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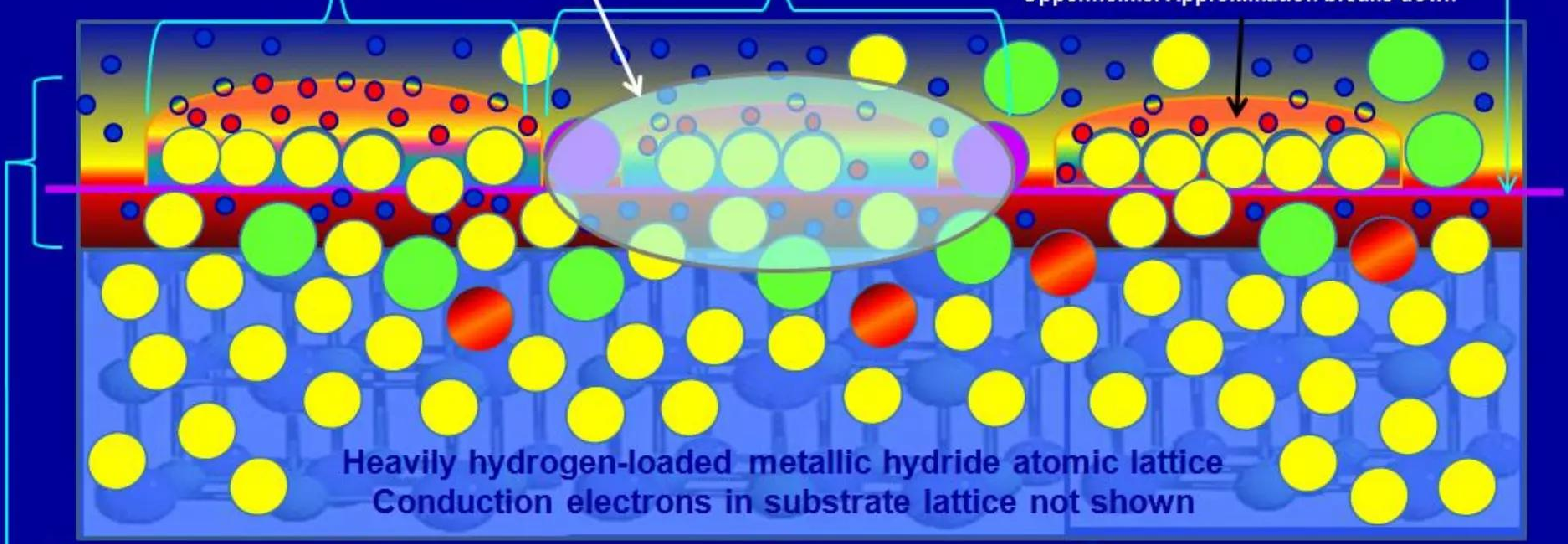
Overview: Widom-Larsen theory of LENRs



Collectively oscillating many-body patch of protons or deuterons with nearby heavy mass-renormalized SP electrons bathed in very high local E-field > 2 x 10^{11} V/m

A proton has just reacted with a SP electron, creating a ghostly ULM neutron via $e^* + p$ weak interaction; QM wavelength same size as patch

Q-M wave function of ultra low momentum (ULM) neutron

Surface of metallic hydride substrate

Local region of very high (>10^{11} V/m) electric fields above micron-scale, many-body patches of protons or deuterons where Born-Oppenheimer Approximation breaks down

Region of short-range, high strength E-M fields and entangled QM wave functions of hydrogenous ions and SP electrons

- ● = Proton, deuteron, or triton
- ● = Surface target atom
- ● = Transmuted atom (nuclear product)
- ⬭ = ULM neutron
- ● = Unstable isotope
- ● = SP electron
- ● = Heavy SPP electron

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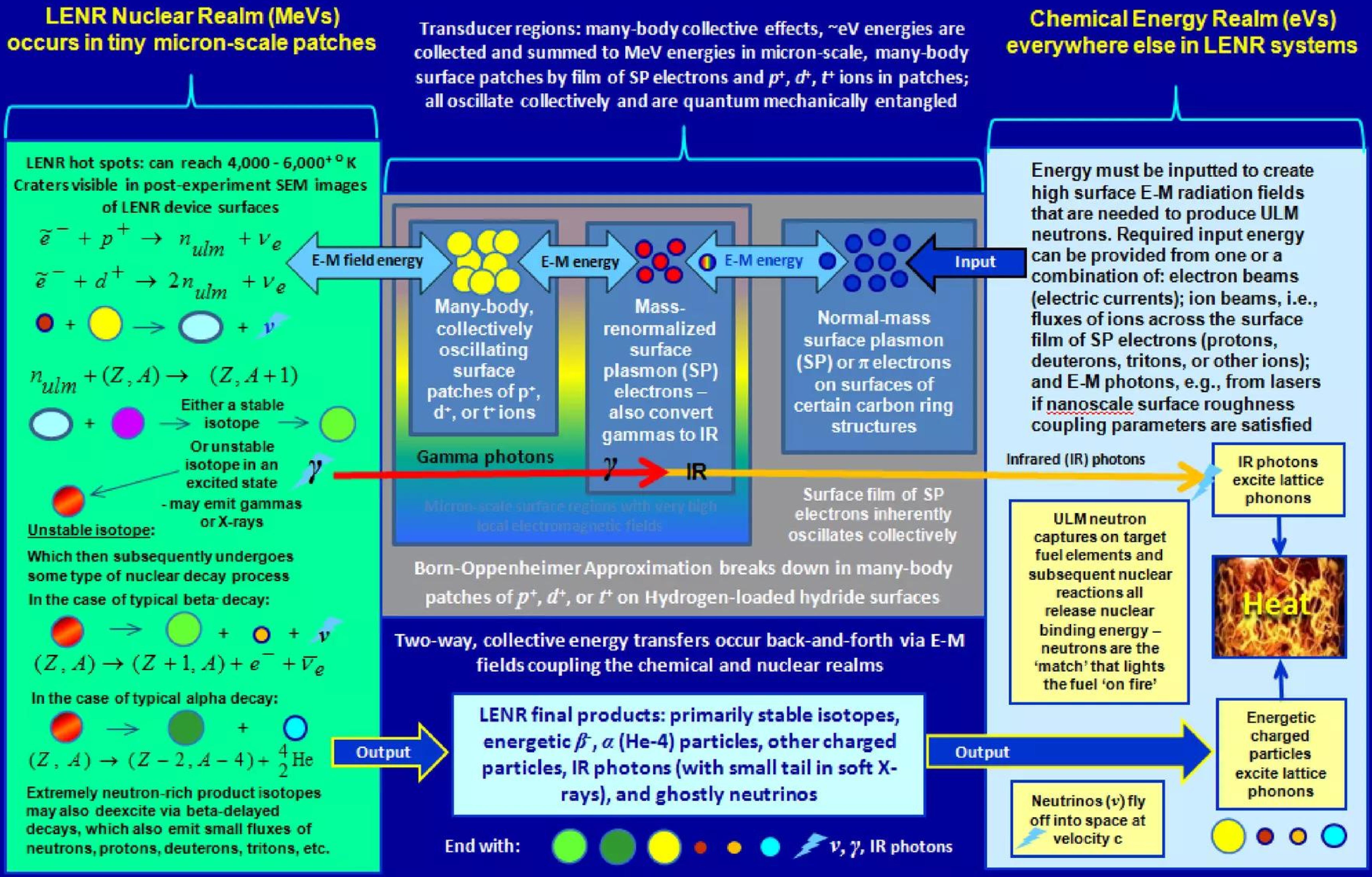
Overview: Widom-Larsen theory of LENRs



LENR Nuclear Realm (MeVs) occurs in tiny micron-scale patches

Transducer regions: many-body collective effects, ~eV energies are collected and summed to MeV energies in micron-scale, many-body surface patches by film of SP electrons and p^+, d^+, t^+ ions in patches; all oscillate collectively and are quantum mechanically entangled

Chemical Energy Realm (eVs) everywhere else in LENR systems

LENR hot spots: can reach 4,000 - 6,000+ °K
Craters visible in post-experiment SEM images of LENR device surfaces

$\tilde{e}^- + p^+ \rightarrow n_{ulm} + \nu_e$

$\tilde{e}^- + d^+ \rightarrow 2n_{ulm} + \nu_e$

● + ● → ● + ν

$n_{ulm} + (Z,A) \rightarrow (Z,A+1)$

● + ● → Either a stable isotope → ●

Or unstable isotope in an excited state - may emit gammas or X-rays ● γ

Unstable isotope:

Which then subsequently undergoes some type of nuclear decay process

In the case of typical beta⁻ decay:

● → ● + ● + ν

$(Z,A) \rightarrow (Z+1,A) + e^- + \bar{\nu}_e$

In the case of typical alpha decay:

● → ● + ●

$(Z,A) \rightarrow (Z-2,A-4) + {}^{4}_{2}\mathrm{He}$

Extremely neutron-rich product isotopes may also deexcite via beta-delayed decays, which also emit small fluxes of neutrons, protons, deuterons, tritons, etc.

E-M field energy

E-M energy

E-M energy

Input

Many-body, collectively oscillating surface patches of p^+, d^+, or t^+ ions

Mass-renormalized surface plasmon (SP) electrons – also convert gammas to IR

Normal-mass surface plasmon (SP) or π electrons on surfaces of certain carbon ring structures

Gamma photons

γ → IR

Micron-scale surface regions with very high local electromagnetic fields

Surface film of SP electrons inherently oscillates collectively

Born-Oppenheimer Approximation breaks down in many-body patches of p^+, d^+, or t^+ on Hydrogen-loaded hydride surfaces

Two-way, collective energy transfers occur back-and-forth via E-M fields coupling the chemical and nuclear realms

Energy must be inputted to create high surface E-M radiation fields that are needed to produce ULM neutrons. Required input energy can be provided from one or a combination of: electron beams (electric currents); ion beams, i.e., fluxes of ions across the surface film of SP electrons (protons, deuterons, tritons, or other ions); and E-M photons, e.g., from lasers if nanoscale surface roughness coupling parameters are satisfied

Infrared (IR) photons

IR photons excite lattice phonons

ULM neutron captures on target fuel elements and subsequent nuclear reactions all release nuclear binding energy – neutrons are the 'match' that lights the fuel 'on fire'

Heat

Energetic charged particles excite lattice phonons

Output

LENR final products: primarily stable isotopes, energetic β^-, α (He-4) particles, other charged particles, IR photons (with small tail in soft X-rays), and ghostly neutrinos

Output

Neutrinos (ν) fly off into space at velocity c

End with: ● ● ● ● ● ● ν, γ, IR photons

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Overview: Widom-Larsen theory of LENRs

LENR-active sites comprise microscopic regions on surfaces

LENR-active surface sites in condensed matter are not permanent entities or static structures; in fact, they are extraordinarily dynamic, short lived, many-body collective organizations of matter. In experimental or certain natural systems with sufficient input energy, when conditions are just right they will form spontaneously, operate for as little as 10 *ns* up to perhaps several hundred nanoseconds, and then suddenly 'die' (they effectively destroy themselves with heat).

Over time or the course of a given experiment, many cycles of 'birth', nuclear binding energy release, and 'death' may be repeated over and over again at many different, randomly scattered *nm*-to *μm*-sized locations found on an LENR-active surface or interface; neutron-dose histories can vary greatly over small length-scales across an entire LENR-active surface. Such spatial elemental/isotopic heterogeneity has often been observed by LENR researchers with SIMS.

While ULM neutron production and local capture, gamma conversion to IR by heavy electrons, and subsequent nuclear decays are occurring, these tiny patches temporarily become hot spots. Their temperatures may briefly reach 4,000 - 6,000° K or perhaps even higher. That value is roughly as high as the surface temperature of the Sun and hot enough to melt and/or even flash-boil essentially all metals and alloys, including Tungsten (b.p. 5,666° C). For a brief time, a tiny dense ball of very hot, nanodusty plasma is created. Such intense local heating events can produce various types of distinctive explosive melting features and/or comparatively deep craters that are often observed in post-experiment SEM images of LENR device surfaces; for example, please see Zhang & Dash's SEM-EDX image of such surface features on Slide #69 in http://www.slideshare.net/lewisglarsen/lattice-energy-llctechnical-overviewjune-25-2009

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Overview: Widom-Larsen theory of LENRs

Absence of strong radiation signatures renders LENRs unnoticeable

- ✓ Unlike fission and fusion reactions, naturally occurring LENR transmutation processes in condensed matter are biologically benign because they make extensive use of and are enabled by many-body collective effects, quantum phenomena, and the weak interaction. As a result, they typically do not emit dangerous high-energy gamma photon or neutron radiation, nor do they produce large amounts of long-lived radioactive isotopes. LENRs are clean, green, ubiquitous, and effectively hidden in plain sight; best way to detect subtle effects of these processes is to analyze samples with very sensitive mass spectroscopy.
- ✓ In a 2012 Lattice PowerPoint presentation http://www.slideshare.net/lewisglarsen/lattice-energy-llcnew-russian-data-supports-wlt-neutron-production-in-lightningapril-4-2012 on Slide #68 we stated that, "Recently, greatly increased use of various types of mass spectroscopy by geochemists, microbiologists, and environmental scientists has revealed that the longstanding assumption of effective natural uniformity of U^{238}/U^{235} ratios across the earth is clearly erroneous; importantly, present-era abiological and/or biologically mediated processes appear to be responsible for such anomalous variances." We concluded that key remaining questions were whether, " ... anomalous variances in such isotopic ratios the result of purely chemical 'fractionation' process or processes of some sort, and/or could they [alternatively] be caused by low energy nuclear reactions (LENRs), either abiologically or somehow induced by the actions of bacteria through some yet to be clarified mechanism?" A large array of additional measurements is obviously needed.

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Overview: Widom-Larsen theory of LENRs

Following required to create right conditions for LENR-active surfaces

- ✓ **Metallic substrates:** substantial quantities of Hydrogen isotopes must be brought into intimate contact with fully-loaded metallic hydride-forming metals; e.g., Palladium, Platinum, Rhodium, Nickel, Titanium , Tungsten, etc.; please note that collectively oscillating, very roughly 2-D surface plasmon (SP) electrons are intrinsically present and cover exposed surfaces of such metals. At full loading occupation of ionized Hydrogen at interstitial sites in bulk metallic lattices, many-body, collectively oscillating patches of protons (p^+), deuterons (d^+), or tritons (t^+) will then form spontaneously at random locations scattered across metal hydrides' surface interfaces;

- ✓ **And/or certain types of Carbon substrates:** delocalized, many-body collectively oscillating π electron clouds that comprise outer covering surfaces of fullerenes, graphene, benzene, and polycyclic aromatic hydrocarbon (PAH) molecules behave very similarly to SPs; when such Carbon-based molecules are hydrogenated (i.e., chemically protonated), they can create many-body, collectively oscillating, Q-M entangled quantum systems that, in context of the Widom-Larsen theory of LENRs, are functionally equivalent to and behave dynamically like loaded metallic hydrides;

- ✓ **Breakdown of Born-Oppenheimer approximation:** in both cases above, occurs in tiny surface patches of contiguous collections of collectively oscillating p^+, d^+, and/or t^+ ions; enables E-M coupling between nearby SP or alternatively delocalized π electrons and nearby hydrogenous ions; patches create their own local nuclear-strength electric fields; effective masses of coupled patch electrons are then increased to a significant multiple of an electron at rest ($e^- \rightarrow e^{-*}$) that is determined by required simultaneous energy input(s); and

- ✓ **Disequilibrium input energy:** triggering LENRs requires external non-equilibrium fluxes of charged particles or electromagnetic (E-M) photons that transfer input energy directly to many-body SP or π electron plasmonic surface films. Examples of such external energy sources include (they may be used in combination): electric currents (electron beams); E-M photons (e.g., emitted from lasers, IR radiation from resonant E-M cavity walls, etc.); pressure gradients of p^+, d^+, and/or t^+ ions imposed across surfaces; currents of other ions crossing the SP electron surface film in either direction (ion beams); etc. Such sources provide additional input energy required to surpass certain minimum H-isotope-specific electron-mass thresholds that allow production of ULM neutron fluxes via $e^{-*} + p^+$, $e^{-*} + d^+$, or $e^{-*} + t^+$ electroweak nuclear reactions.

Overview: Widom-Larsen theory of LENRs

LENR-active surfaces host many dynamically interacting processes

- ✓ LENR hot spots create intense local heating and variety of readily noticeable surface features such as craters: over time, LENR-active surfaces inevitably experience major micron-scale changes in local nanostructures and elemental/isotopic compositions. On LENR-active substrate surfaces, there are a myriad of different complex, nanometer-to micron-scale electromagnetic, chemical, and nuclear processes that operate in conjunction with and simultaneously with each other. LENRs involve interactions between surface plasmon electrons, E-M fields, and many different types of nanostructures with varied geometries, surface locations relative to each other, different-strength local E-M fields, and varied chemical/isotopic compositions; chemical and nuclear realms interoperate
- ✓ To varying degrees, many of these complex, time-varying surface interactions are electromagnetically coupled on many different physical length-scales: thus, mutual E-M resonances can be very important in such systems. In addition to optical frequencies, SP and π electrons in condensed matter often also have some absorption and emission bands in infrared (IR) and UV portions of E-M spectrum. Well, walls of gas-phase metallic or glass LENR reaction vessels can emit various wavelengths of E-M photon energy into the interior space; glass tubes with inside surfaces coated with complex phosphors can function as resonant E-M cavities. Target nanostructures, nanoparticles, and/or molecules located inside such cavities can absorb IR, UV, or visible photons radiated from vessel walls if their absorption bands happen (or are engineered) to fall into same spectral range as E-M cavity wall radiation emission; complex two-way E-M interactions between targets and walls occurs (imagine interior of a reaction vessel as arrays of E-M nanoantennas with walls and targets having two-way send/receive channels)
- ✓ Wide variety of complex, interrelated E-M, nuclear, and chemical processes may be occurring simultaneously, side-by-side in adjacent *nm* to *μ*-scale local regions on LENR-active surfaces: for example, some regions on a given surface may be absorbing E-M energy locally, while others nearby can be emitting energy (e.g., as energetic electrons, photons, other charged particles, etc.). At the very same time, energy can be transferred laterally from regions of resonant absorption or capture to other regions in which emission or consumption is taking place, e.g., photon or electron emission, and/or LENRs in which [E-M field energy] + $e^- \rightarrow e^{-*} + p^+ \rightarrow n_{ulm} + \nu$

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Overview: Widom-Larsen theory of LENRs

LENR reaction rates can be increased by controlling key parameters

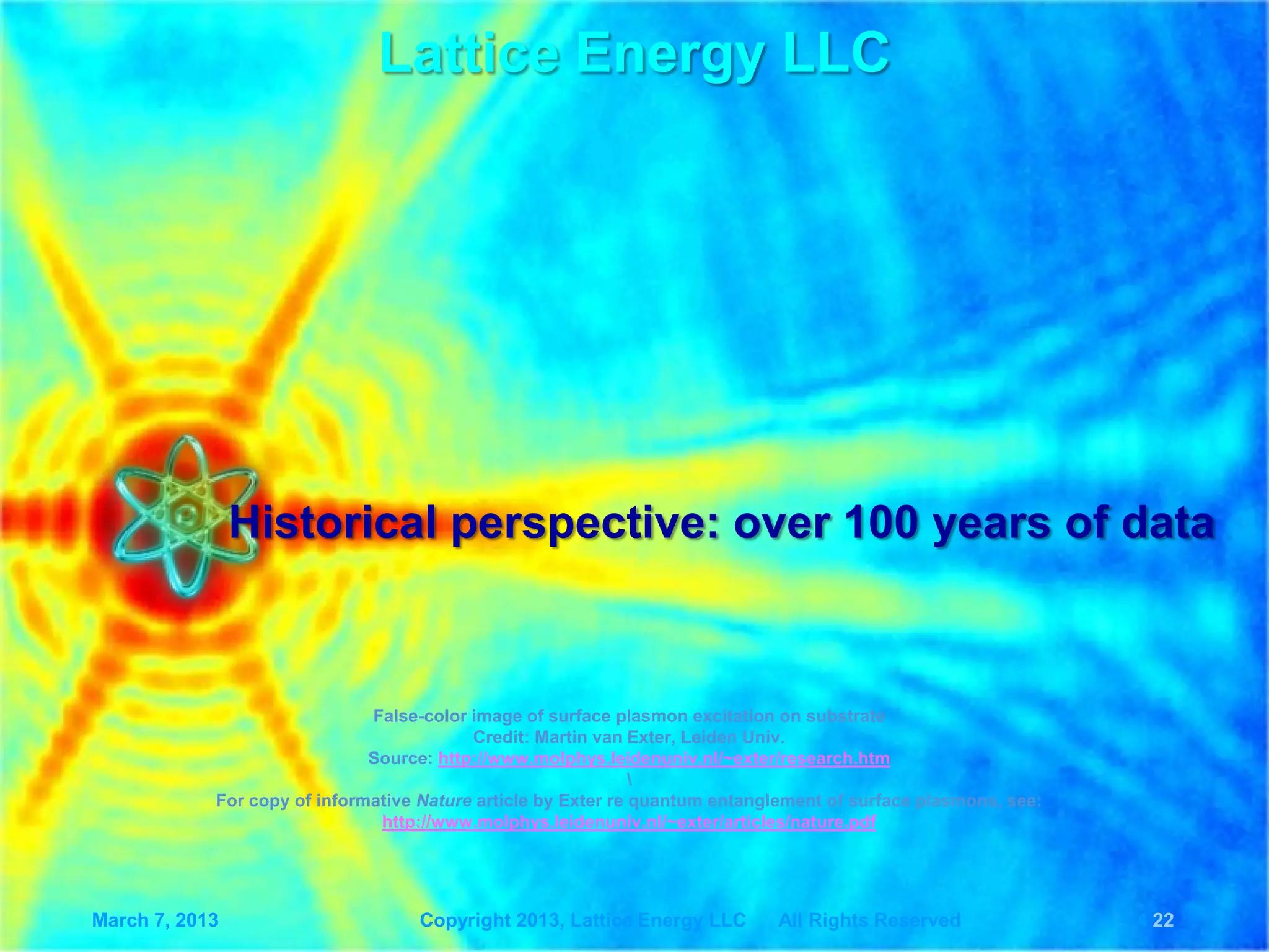
- ✓ Using conceptual insights provided by the WLT, experimental conditions in condensed matter systems and dusty plasmas can be technologically tweaked to increase rates of weak reaction neutron production vastly above whatever levels might ever be attainable in analogous systems found at random out in Nature or the myriad of LENR laboratory experiments that have been conducted to date

- ✓ It is known within the field of LENRs that, under exactly the right conditions and in a number of different types of experimental systems (e.g., rare well-performing current-driven aqueous H_2O/D_2O electrolytic chemical cells), rates of transmutation product production (which according to WLT are very closely related to parallel rates of many-body, collective electroweak reaction ULM neutron production) can be quite substantial. Measured indirectly via qualitative and quantitative assays of LENR transmutation products, estimates of experimentally observed, effectively neutron production rates reported by LENR researchers range from ~10^9 - 10^{10} cm^2/sec up to ~10^{12} - 10^{16} cm^2/sec in a small subset of very well-performing experimental systems

- ✓ In 2007, Widom & Larsen published first-principles calculations which show that substantial ULM neutron production rates via such electroweak reactions are theoretically possible in condensed matter systems under such mild conditions; calculated results for such rates in a model electrolytic chemical cell (on the order of 10^{12} to 10^{14} neutrons cm^2/second) are thus in good agreement with the best available published experimental data; again please see arXiv preprint at: http://arxiv.org/PS_cache/nucl-th/pdf/0608/0608059v2.pdf

- ✓ Technologically, many-body collective electroweak neutron production rates can be directly manipulated by: (1) controlling total numbers and density of e^-p^+ pairs on a given surface (which is ~equivalent to controlling the area-density and dimensions of many-body, collectively oscillating surface patches of protons or deuterons); and (2) controlling the rate and total quantity of appropriate form(s) of nonequilibrium energy input into LENR-active patches; appropriate forms of input energy can go directly into high electric fields that bathe SP electrons in a patch --- it determines the number and effective masses of e^* electrons present in a given patch whose increased masses are at values somewhere above the minimum mass-renormalization threshold ratio, β_0 that is required for initiating $e^* + p^+$ or $e^* + d^+$ electroweak neutron production reactions. The term $(\beta - \beta_0)^2$ in our published LENR rate equation reflects the degree to which mass renormalized e^* electrons in a given patch exceed the minimum threshold ratio for electroweak neutron production β_0. Rigorous details of supporting calculations are explained in: http://arxiv.org/PS_cache/nucl-th/pdf/0608/0608059v2.pdf

All other things being equal, the higher the density of e^-p^+ reactants and the greater the rate and quantity of appropriate forms of nonequilibrium energy inputs, the higher the rate of ULM neutron production in nm- to μ-scale LENR-active patches in an appropriately pre-configured condensed matter system



Historical perspective: over 100 years of data

False-color image of surface plasmon excitation on substrate
Credit: Martin van Exter, Leiden Univ.
Source: http://www.molphys.leidenuniv.nl/~exter/research.htm
\
For copy of informative *Nature* article by Exter re quantum entanglement of surface plasmons, see:
http://www.molphys.leidenuniv.nl/~exter/articles/nature.pdf

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Historical perspective: over 100 years of data

Alchemy was not always thought to be a questionable area of inquiry

“The delusion of transmutation”

“As we peer down the vista of the past we find the delusion of transmutation holding the most prominent place in the minds of thinking men. Frenzied alchemy held the world in its grip for seventeen centuries and more of recorded history. This pseudoscience with its alluring goal and fascinating mysticism dominated the thoughts and actions of thousands. In the records of intellectual aberrations it holds a unique position. Even Roger Bacon of Oxford, easily the most learned man of his age, the monk who seven hundred years ago foresaw such modern scientific inventions as the steamship and the flying machine, believed in the possibility of solving this all-consuming problem … Sir Isaac Newton, one of the clearest scientific thinkers of all time, bought and consulted books on alchemy as late as the eighteenth century … The power and the influence of many of the alchemists can hardly be exaggerated … While among the alchemists there were some genuine enthusiasts like Bernard Trevisan, the annals of this queer practice are filled with accounts of charlatans and spurious adepts who, with a deluge of glib words but with only a drop of truth, turned alchemy into one of the greatest popular frauds in history.”

Bernard Jaffe, “Crucibles: the story of chemistry” 4th Revised ed., pp. 7-8 Dover 1976

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Historical perspective: over 100 years of data

1901: Discovery of modern nuclear alchemy by Soddy & Rutherford

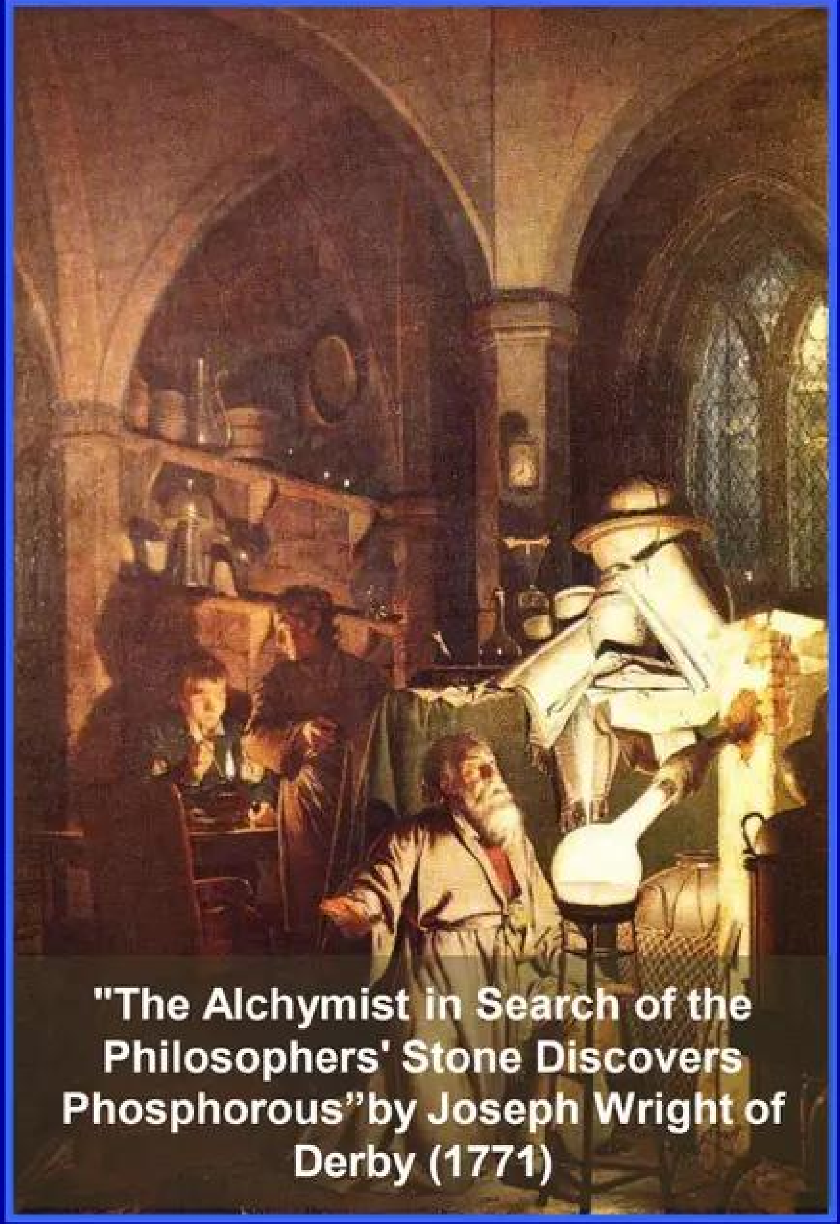
"For Mike's sake Soddy, don't call it transmutation.
They'll have our heads off as alchemists."

Comment made by Ernest Rutherford to Frederic Soddy in 1901; Rutherford subsequently received Nobel prize in chemistry in 1908

"The Alchemist's Workshop" by Jan van der Straet (1570)

"In 1901, twenty-four year-old chemist Frederick Soddy and Ernest Rutherford were attempting to identify a mysterious gas that wafted from samples of radioactive thorium oxide. They suspected that this gas - they called it an 'emanation' - held a key to the recently discovered phenomenon of radioactivity. Soddy had passed the puzzling gas over a series of powerful chemical reagents, heated white-hot. When no reactions took place, he came to a startling realization. As he told his biographer many years later, ´I remember quite well standing there transfixed as though stunned by the colossal import of the thing and blurting out-or so it seemed at the time, 'Rutherford, this is transmutation: the thorium is disintegrating and transmuting itself into argon gas.' Rutherford's reply was typically aware of more practical implications."

J. Magill, "Decay Engine" at www.nucleonica.net



"The Alchymist in Search of the Philosophers' Stone Discovers Phosphorous"by Joseph Wright of Derby (1771)

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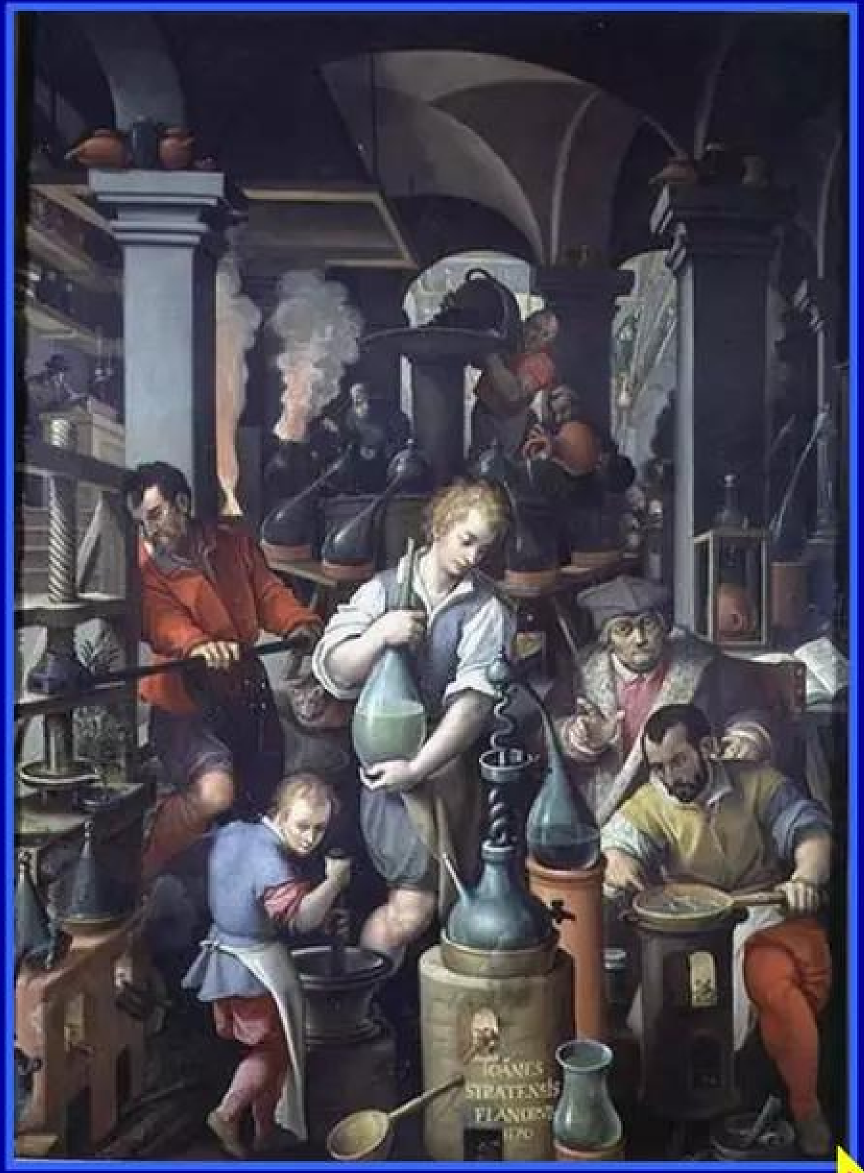
Historical perspective: over 100 years of data

1920: Rutherford predicts neutron and its creation via electric discharges

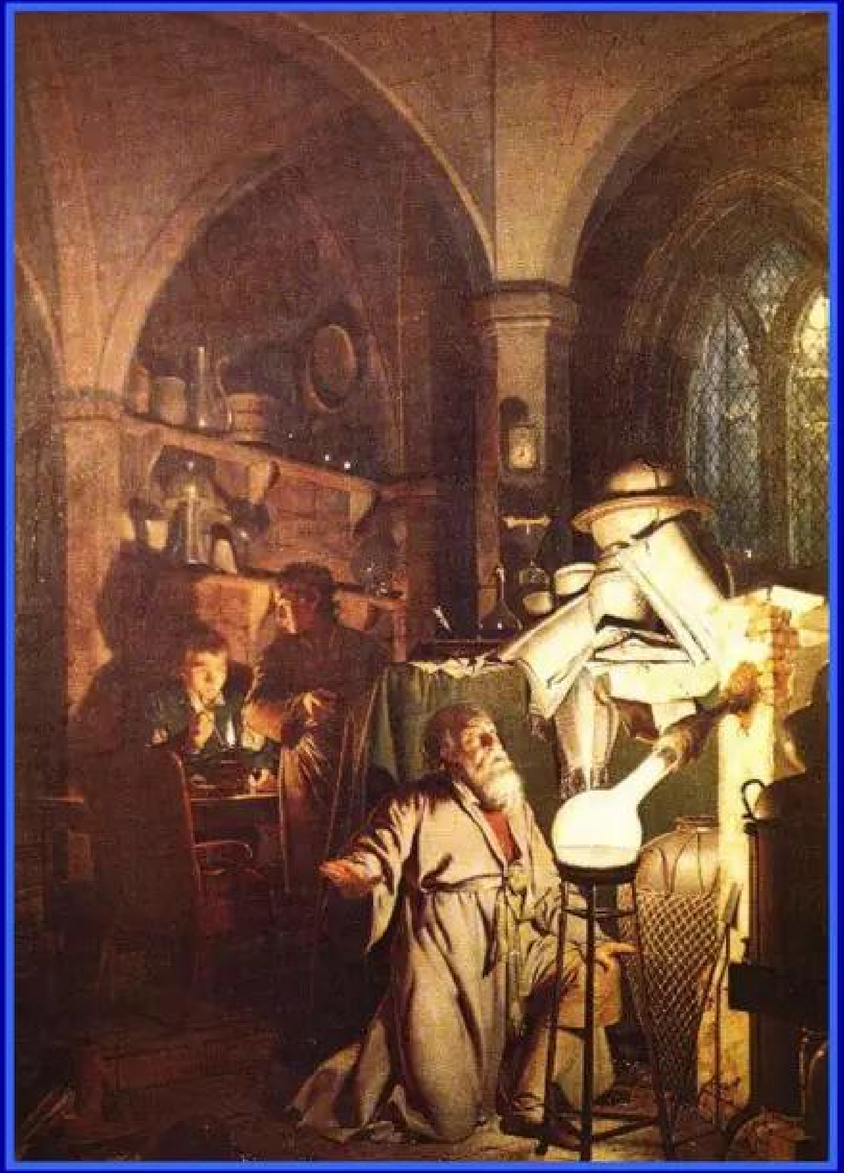
"On present views, the neutral hydrogen atom is regarded as a nucleus of unit charge with an electron attached at a distance, and the spectrum of hydrogen is ascribed to the movements of this distant electron. Under some conditions however, it may be possible for an electron to combine much more closely with the H nucleus, forming a kind of neutral doublet [neutron]. Such an atom would have very novel properties. Its external field would be practically zero, except very close to the nucleus, and in consequence it should be able to move freely through matter. Its presence would be difficult to detect by the spectroscope, and it may be impossible to contain in in a sealed vessel. On the other hand, it should enter readily the structure of atoms, and may either unite with the nucleus [now called neutron capture] or be disintegrated by its intense field, resulting in possibly the escape of a charged H atom [now called proton emission] or an electron [now called beta particle emission] or both."

2nd Bakerian lecture was given in London on June 20, 1920



"Nuclear constitution of atoms"
Ernest Rutherford
Proc. Roy. Soc. **pp. 577 - 585 (1920)**
http://web.ihep.su/dbserv/compas/src/rutherford20/eng.pdf

Quoting further (his next statement is utterly astounding):
"If the existence of such atoms [he is referring to neutrons here] be possible, it is to be expected that they may be produced, but probably in only very small numbers, in the electric discharge through hydrogen, where both electrons and H nuclei are present in considerable numbers. It is the intention of this writer to make experiments to test whether any indication of the production of such atoms [read 'neutrons'] can be obtained under these conditions."



Comment: Rutherford is saying that neutrons could be produced by intense electric discharges in Hydrogen

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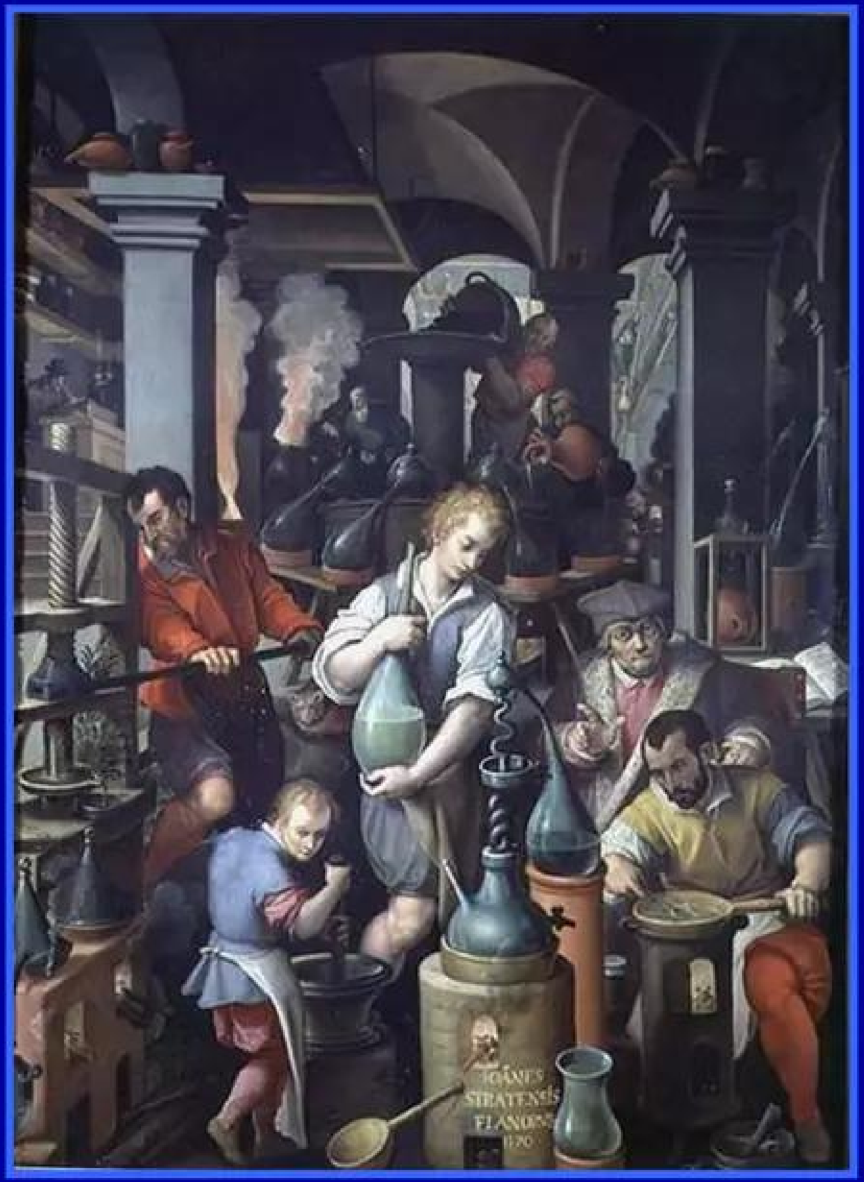
Historical perspective: over 100 years of data

1922: Wendt & Irion see Helium spectroscopically in exploding W wire

“Experimental attempts to decompose Tungsten at high temperatures”

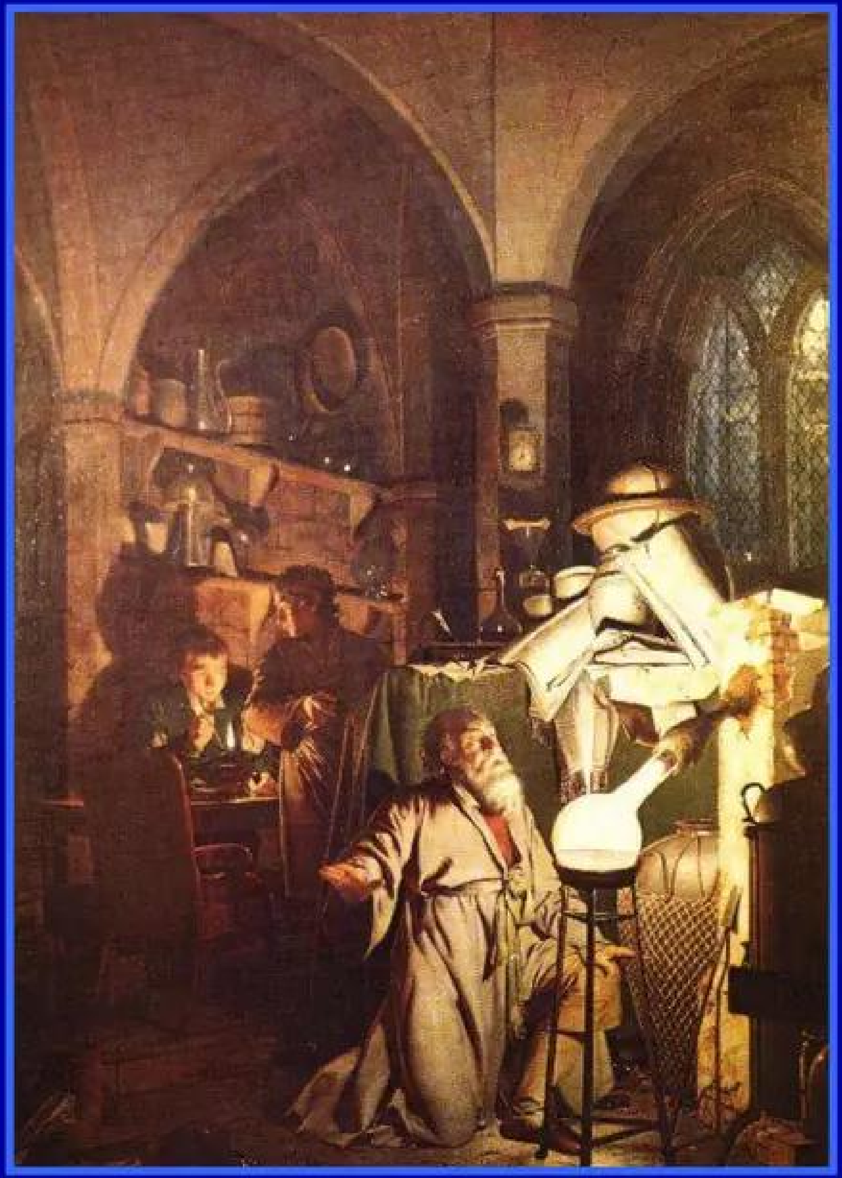
“This has become possible through the work of Anderson whose method of exploding wires at temperatures above 20,000^{o}, well above that attributed to the hottest stars, has become valuable in spectroscopy. In our application of this method the [Tungsten] wires were exploded within strong glass bulbs so that the gaseous products of the explosions could be collected for analysis. The method thus includes factors, both of cause and of error, analogous to those operative in the voluminous and inconclusive controversy on the evolution of helium in various types of low pressure discharge tubes, extending from 1903 to 1915.”

***American Chemical Society* 44 pp. 1887 - 1894 (1922)**



Quoting further: “The bulb was then connected to the leads from the condenser through the spark gap and the wire was exploded by closing the primary circuit of the transformer. There was a delay of a fraction of a second before the condenser was fully charged to the voltage used, about 30,000, but thereafter the wire disappeared in a brilliant flash … [conclusion] When fine Tungsten wires are exploded in a vacuum at such temperatures, the spectrum of Helium appears in the gases produced.”

Comment: Wendt & Irion’s results were discredited by an attack that Rutherford published in *Nature*. This stopped their work and effectively ended their careers. In 2006, we reanalyzed their data in light of the Widom-Larsen theory and discovered that their experimental results were most likely correct and Rutherford’s criticisms were wrong. Please see our 2007 arXiv preprint on exploding wires for details.



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Historical perspective: over 100 years of data

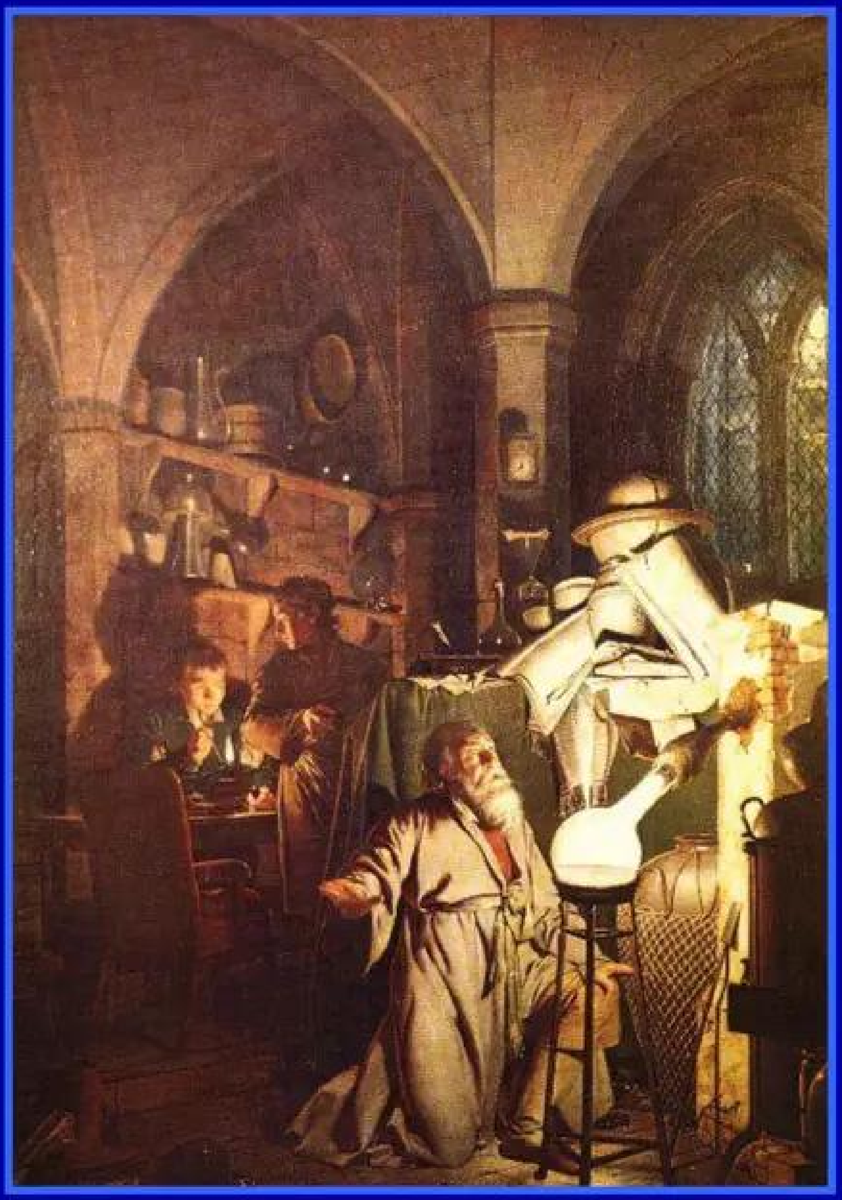
1923: after winning Nobel prize, Millikan excited about transmutations

"As early as 1912, Dr. Winchester and I thought we had good evidence that we were knocking hydrogen out of aluminum and other metals by very powerful electric discharges *in vacuo* … How much farther can we go in this artificial transmutation of elements? This is one of the supremely interesting problems of modern physics upon which we are all assiduously working."

Comment made on pp. 584 by Robert Millikan, then at Caltech, as written in his *Scribner's* magazine article

"Gulliver's travels in science"
Robert Millikan
***Scribner's* pp. 577 - 585 (Nov. 1923)**
http://www.unz.org/Pub/Scribners-1923nov-00577

Quoting further: "… Has nature a way of making these transmutations in her laboratories? She is doing it under our eyes in the radioactive process … Does the process go on in both directions, heavier atoms being continually formed, as well as continually disintegrating into lighter ones? Not on earth, so far as we can see. Perhaps in God's laboratories, the stars. Some say we shall be finding out."



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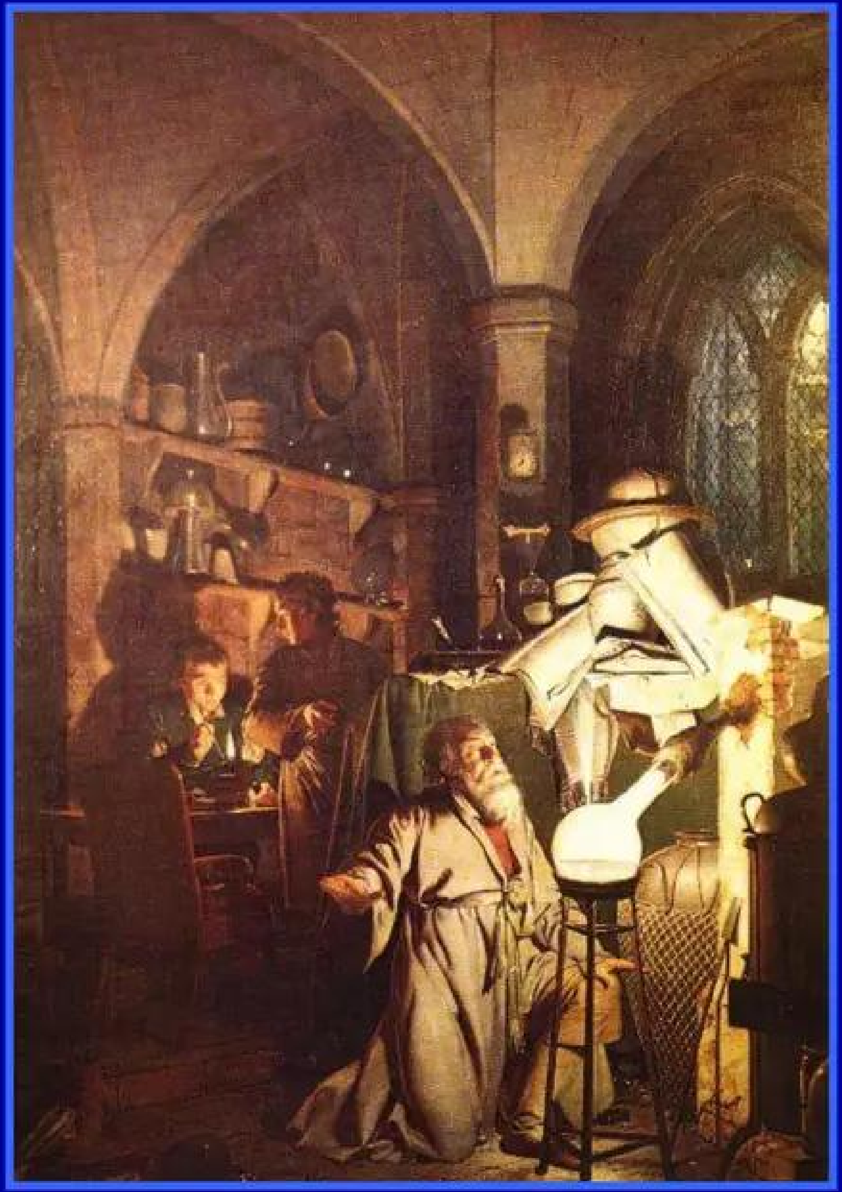
Historical perspective: over 100 years of data

1924: Soddy, now famous, discusses new transmutation experiments

"Indeed, for some time before Prof. Miethe's announcement it has been clear to me that, by passing a sufficiently high tension discharge though mercury vapor, not merely that such a transmutation might occur, but that it was inevitable, unless our present views on atomic structure are radically at fault."

Comment made by Soddy in *Nature* article; had already received Nobel prize in chemistry in 1921

"The reported Transmutation of Mercury into Gold"
Frederic Soddy
***Nature* 114 pp. 244 - 245 (1924)**



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Historical perspective: over 100 years of data

1924: Gaschler claims transmutation of Gold into Mercury with protons

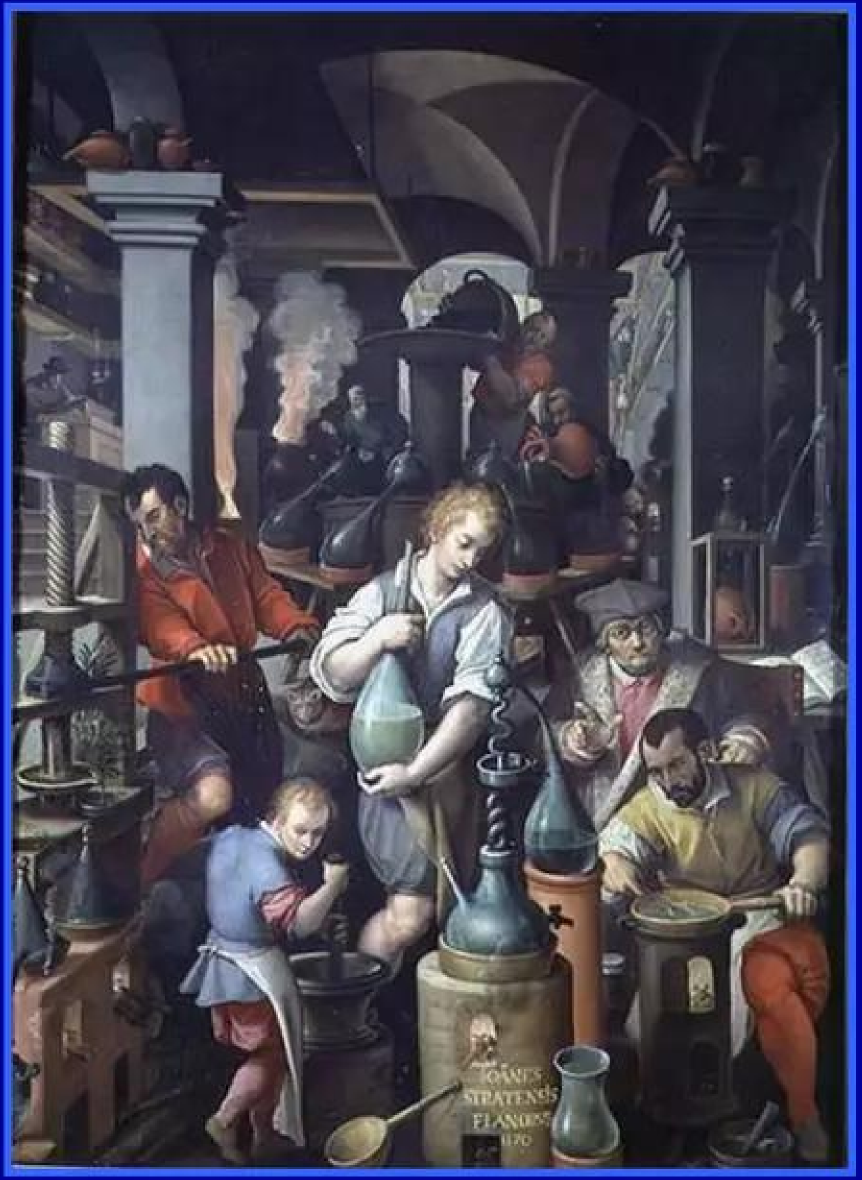
"Der zerfall des quecksilberatoms"

[Translated from German: The decay of the Mercury atom]

Alois Gaschler

Summary: Gold was sealed into vacuum tube and bombarded with protons; after 30 hours, Mercury line appeared in spectrum and became progressively stronger over time. Oil pump used to produce vacuum - hydrocarbons were likely present on the Gold

Angewandte Chemie **37 pp. 666 - 667 (1924) now online at: http://onlinelibrary.wiley.com/doi/10.1002/ange.v37:35/issuetoc**



Also see:

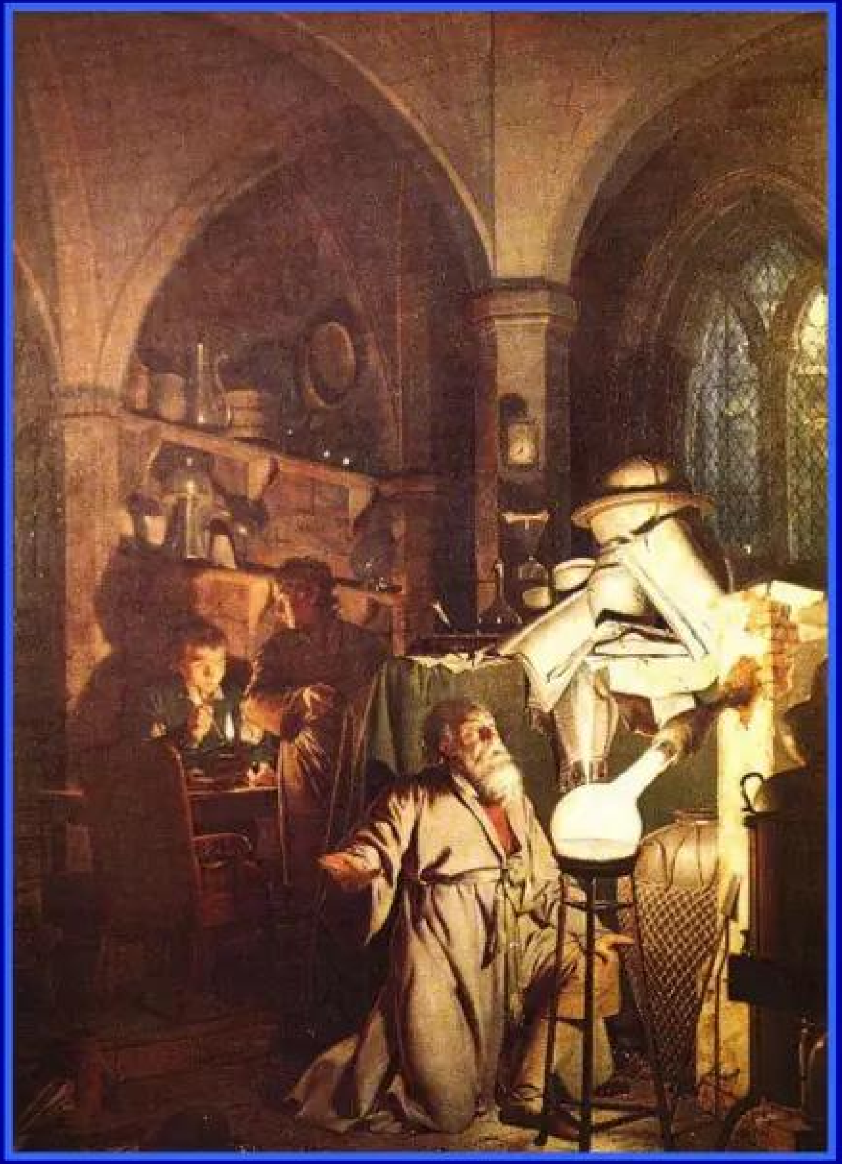
"Gold changed to Mercury by German physicist"
Journal of Chemical Education **3 pp. 679 (1926)**
DOI: 10.1021/ed003p679

Comment:

Gaschler was also issued U.S. patent on transmutation-related novel subject matter art as follows:

US Patent # 1,644,370
"Method of Artificially Producing Radioactive Substances"
Oct. 4, 1927 [filed September 4, 1924]
http://www.freepatentsonline.com/1644370.pdf

Claim #5: "A process for increasing radioactivity of materials which comprises vaporizing said materials by heating said materials to a high temperature by means of a current of low voltage and high intensity and submitting said vapors to contact with relatively large electrodes and passing a high tension low intensity current between said electrodes."



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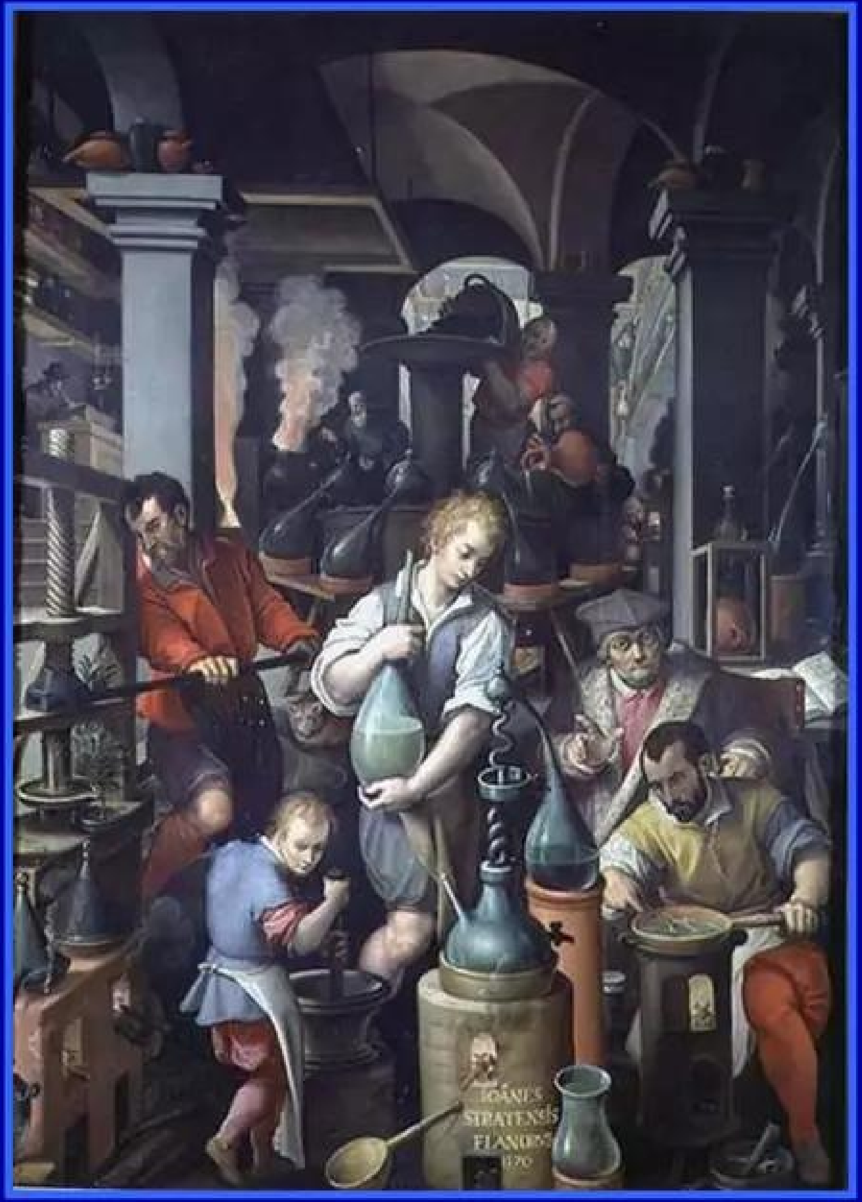
Historical perspective: over 100 years of data

1925: Nagaoka sees Gold from Tungsten electrodes w. electric arcs in oil

"Preliminary note on the transmutation of Mercury into Gold"
Hantaro Nagaoka
***Nature* 116 pp. 95 - 96 (1925)**



"The [high-current electric arc] experimental procedure here sketched cannot be looked upon as the only one for effecting transmutation [of other elements into Gold]; probably different processes will be developed and finally lead to industrial enterprises … Experiments with various elements may lead to different transmutations, which will be of significance to science and industry. Meagre as is the result, I wish to invite the attention of those interested in the subject so that they may repeat the experiment with more powerful means than are available in the Far East."

Prof. Hantaro Nagaoka in "Letters to the Editor"
Nature July 18, 1925

World famous Japanese physicist

Historical perspective: over 100 years of data

1925: Nagaoka sees Gold from Tungsten electrodes w. electric arcs in oil

- ✓ Unlike, the comparatively unknown Wendt & Irion team at the U. of Chicago, Nagaoka was a world-renowned physicist and one of the most preeminent scientists in Japan when he began his high-current discharge transmutation experiments in September 1924
- ✓ For an appreciation of Hantaro's high scientific stature, please see Wikipedia article: http://en.wikipedia.org/wiki/Hantaro_Nagaoka
- ✓ Nagaoka was contemporary competitor of Ernest Rutherford; Hantaro's *"*Saturn model" of the atom was *only* competing model cited by Rutherford in his seminal 1911 paper on atomic nuclei
- ✓ Given the very international character of science even at that time, it is very likely that Nagaoka was aware of worldwide controversy swirling around Wendt & Irion's exploding wire experiments and of Rutherford's short but devastating critical attack on them in *Nature*
- ✓ It is also quite likely that Hantaro was aware of Robert Millikan's well-publicized views on subject of triggering transmutations with electric arcs (note: Millikan had just won a Nobel prize in physics)
- ✓ Lastly, he must have known about Miethe & Stammreich's work in Germany; they claimed to have changed Mercury into Gold in a high-voltage Mercury vapor lamp, "The reported transmutation of Mercury into Gold," *Nature* 114 pp. 197 - 198 (1924)

Please see:

*"*Preliminary note on the transmutation of Mercury into Gold," H. Nagaoka, *Nature* 116 pp. 95 -96 (18 July 1925)

Available for purchase on *Nature* archives at:

http://www.nature.com/nature/journal/v116/n2907/abs/116095a0.html

Abstract: "The experiment on the transmutation of mercury was begun in September 1924, with the assistance of Messrs. Y. Sugiura, T. Asada and T. Machida. The main object was to ascertain if the view which we expressed in NATURE of March 29, 1924, can be realised by applying an intense electric field to mercury atoms. Another object was to find if the radio-active changes can be accelerated by artificial means. From the outset it was clear that a field of many million volts/cm. is necessary for the purpose. From our observation on the Stark effect in arcs of different metals (*Jap. Journ. Phys*., vol. 3, pp. 45â€“73) we found that with silver globules the field in a narrow space very near the metal was nearly 2 Ã -10^5 volts/cm. with terminal voltage of about 140. The presence of such an intense field indicated the possibility of obtaining the desired strength of the field for transmutation, if sufficient terminal voltage be applied. Though the above ratio of magnification would be diminished with high voltage, the experiment was thought worth trying, even if we could not effect the transmutation with the apparatus at hand."

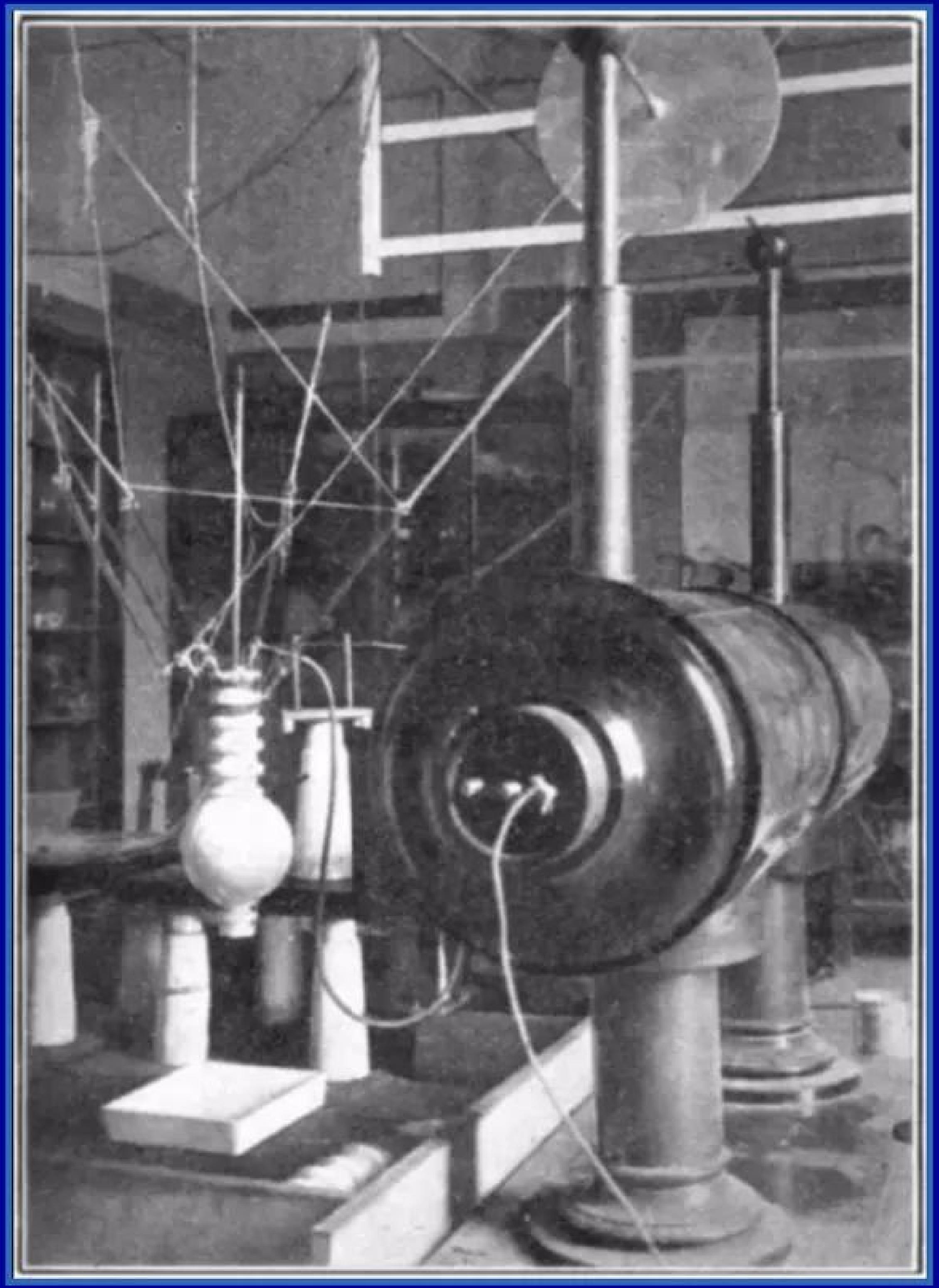
Historical perspective: over 100 years of data

1925: Nagaoka sees Gold from Tungsten electrodes w. electric arcs in oil

Essence of Prof. Nagaoka's experiments:

- ✓ In the simplest terms: Prof. Nagaoka created a powerful electric arc discharge between a spark gap comprising two metallic, Thorium-oxide-free Tungsten (W) electrodes (supplied by Tokyo Electric Company) bathed in a dielectric liquid "paraffin" (today referred to as transformer oil; general formula C_nH_{2n+2}) that was interlaced with liquid native Mercury (Hg)
- ✓ Depending on experiment, arcing between Tungsten electrodes in oil was continued for 4 - 15 hours until, quoting, " … the oil and mercury were mixed into a black pasty mass." Please note that Mercury readily forms amalgams with many different metals, including Gold (Au) and Tungsten (W)
- ✓ Small flecks of Gold were sometimes quite visible to the naked eye in *"*black masses*"* produced at the end of a given experiment. They also noted that, *"*The Gold obtained from Mercury seems to be mostly adsorbed to Carbon.*"*
- ✓ Microscopic assays were conducted by, "heating small pieces of glass with the Carbon," to form a so-called "Ruby glass" that can be used to infer the presence of gold colloids from visual cues very apparent under a microscope
- ✓ Critics complained about the possibility that the Gold observed was some sort of "contamination." Responding to critics, Nagaoka *et al*. further purified literally everything they could think of and also made certain that the lab environs were squeaky clean; they still kept seeing anomalous Gold. Also, in some experiments they also observed, *"*a minute quantity of white metal." Two years later in 1926, Nagaoka reported to *Scientific American* that they had finally been able to identify the "white metal" --- it was Platinum (Pt)

Fig. 1 – Apparatus for the electric discharge
H. Nagaoka, *Nature* July 18, 1925



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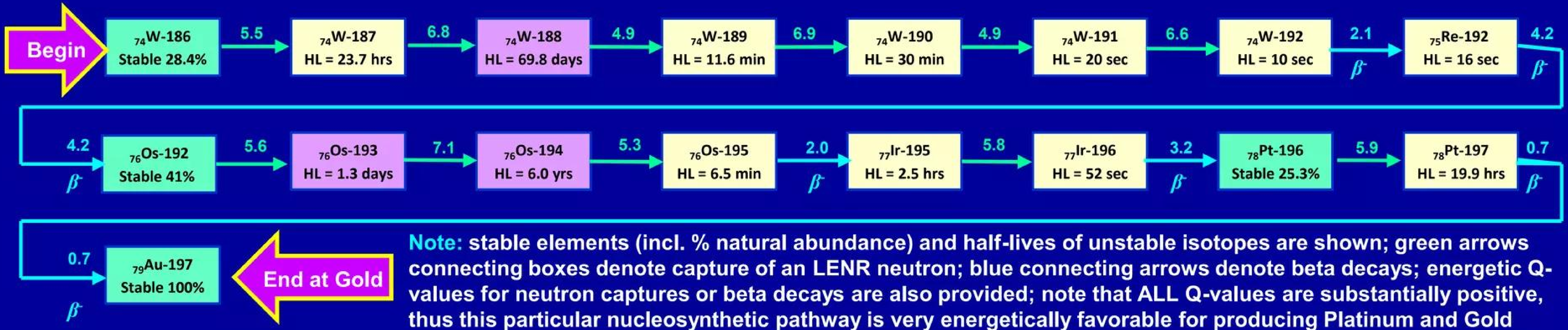
Historical perspective: over 100 years of data

1925: Nagaoka sees Gold from Tungsten electrodes w. electric arcs in oil

Which LENR network could have produced Gold or Platinum from a Tungsten target?

- ✓ **All of the ingredients for LENRs to occur were in fact present: hydride-forming metal found therein was Tungsten (sadly, Nagaoka was unaware that Mercury was more-or-less a red herring); which was in contact with abundant Hydrogen (protons) in transformer oil (C_nH_{2n+2}); the Born-Oppenheimer approximation broke-down on surfaces of electrodes; and finally, there were large non-equilibrium fluxes of charged particles --- electrons in the high-current arc discharges. Unbeknownst to Nagaoka, his high-current arcs probably also produced small amounts of fullerenes, carbon nanotubes, and perhaps even a little graphene. ULM neutron production rates via W-L weak interaction could have been quite substantial in his high-electric-current-driven experimental system because of very large inputs of electrical energy**
- ✓ **What could have happened in Nagaoka's experiments was that Tungsten-seed, ULM neutron-catalyzed nucleosynthetic networks spontaneously formed. What follows is but one example of an energetically favorable network pathway that could produce detectable amounts of the only stable Gold isotope, ${}_{197}$Au, within ~4 hours (shortest arc discharge period after which Au was observed). Other alternative viable LENR pathways can produce unstable Gold isotopes, e.g., ${}_{198}$Au with half-life = 2.7 days and ${}_{199}$Au with HL = 3.1 days (both would be around for a time at end of a successful experiment)**
- ✓ **One possible ${}_{74}W^{180}$-target LENR network pathway that could produce Pt and Au in as little time as 4-5 hrs follows:**



Begin

${}_{74}$W-186 Stable 28.4% → 5.5 → ${}_{74}$W-187 HL = 23.7 hrs → 6.8 → ${}_{74}$W-188 HL = 69.8 days → 4.9 → ${}_{74}$W-189 HL = 11.6 min → 6.9 → ${}_{74}$W-190 HL = 30 min → 4.9 → ${}_{74}$W-191 HL = 20 sec → 6.6 → ${}_{74}$W-192 HL = 10 sec → 2.1 β^- → ${}_{75}$Re-192 HL = 16 sec → 4.2 β^- →

${}_{76}$Os-192 Stable 41% → 5.6 → ${}_{76}$Os-193 HL = 1.3 days → 7.1 → ${}_{76}$Os-194 HL = 6.0 yrs → 5.3 → ${}_{76}$Os-195 HL = 6.5 min → 2.0 β^- → ${}_{77}$Ir-195 HL = 2.5 hrs → 5.8 → ${}_{77}$Ir-196 HL = 52 sec → 3.2 β^- → ${}_{78}$Pt-196 Stable 25.3% → 5.9 → ${}_{78}$Pt-197 HL = 19.9 hrs → 0.7 β^- →

${}_{79}$Au-197 Stable 100%

End at Gold

Note: stable elements (incl. % natural abundance) and half-lives of unstable isotopes are shown; green arrows connecting boxes denote capture of an LENR neutron; blue connecting arrows denote beta decays; energetic Q-values for neutron captures or beta decays are also provided; note that ALL Q-values are substantially positive, thus this particular nucleosynthetic pathway is very energetically favorable for producing Platinum and Gold

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Historical perspective: over 100 years of data

Final remarks re Nagaoka; today Au is produced in catalytic converters

Nagaoka's reported results were probably correct; Gold (Au) and Platinum (Pt) could have been produced by LENRs per W-L theory:

- ✓ **Plausible LENR nucleosynthetic pathway shown in a previous Slide suggests that Nagaoka *et al.*'s claimed observations of macroscopically visible particles of Gold in their *ca.* 1920s electric arc experiments in transformer oil could very well have been correct observations**
- ✓ **Note that stable Gold can also be produced via neutron capture on stable $_{80}Hg^{196}$ which creates unstable $_{80}Hg^{197}$ that has a half-life of 2.7 days and decays via electron capture into stable $_{79}Au^{197}$. However, the natural abundance (0.15%) of $_{80}Hg^{19}$ initially present in Nagaoka's mid-1920s experiments was so low that this alternative LENR pathway cannot plausibly account for observed production of macroscopic flecks of metallic of Au and Pt that are readily visible to the naked human eye**
- ✓ **Please take note of the quotation from Prof. Nagaoka reproduced on earlier Slide. In saying what he said, Hantaro clearly believed that some sort of commercial transmutation technology would eventually be developed at some point in the future. Thus, in our opinion not only was he a humble, brilliant scientist; he was also a rather bold visionary thinker --- truly a man far ahead of his own time**
- ✓ **In the present era it is very possible that minute quantities of Gold are actually being produced in automobile catalytic converters via the transmutation of some Platinum present in the converters: at right, please see citation to a 2003 paper in *Applied Geochemistry* and URL to yet another Lattice SlideShare presentation dated June 25, 2010**

Re other possibly anomalous sources of Gold:

"Occurrence of Platinum, Palladium, and Gold in pine needles of Pinus pinea from the city of Palermo (Italy)"
G. Dongarra, D. Varrica, and G. Sabatino
***Applied Geochemistry* 18 pp. 109-116 (2003)**

Quoting: "Preliminary data on the presence of Pt, Pd and Au in airborne particulate matter from the urban area of Palermo (Sicily, Italy) are presented. They were obtained by analysing 40 samples of pine needles (Pinus pinea L.) collected in and around the city. Observed concentrations range from 1 to 102 µg/kg for Pt, 1 to 45 µg/kg for Pd and 22 to 776 µg/kg for Au. Platinum and Pd concentrations in pine needles are up to two orders of magnitude higher than their crustal abundances. They exhibit a high statistical correlation (R^2=0.74) which suggests a common origin."

"Precious metal concentrations measured within the city centre are much higher than those occurring outside the town. The distribution patterns of Pt and Pd in the study area are compared to the distributions of Au and Pb. Gold is enriched at the same sites where Pt and Pd are enriched, while Pb shows some discrepancies. The most probable local source of all of these elements is traffic. Average Pt and Pd emissions in the city area are estimated to be about 136 and 273 g/a, respectively."

Discussed in Lattice presentation at URL:

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

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Historical perspective: over 100 years of data

1927: Millikan’s Caltech PhD student observed Pb → Hg and Bi → Tl

LENR transmutation of Lead into other elements was observed in experiments

Comment: in Widom-Larsen condensed matter LENR nucleosynthetic network shown earlier, unstable isotopes of Lead and Bismuth will spontaneously transmute into unstable isotopes of Mercury and Thallium, respectively, which could be detected spectroscopically. This was observed and reported by Lars Thomassen in experimental work conducted for his PhD at Caltech under Millikan. Note that Thomassen cites Nagaoka (who was a famous physicist) but does not cite Wendt & Irion; credibility of their exploding wire work in 1922 had already been destroyed by Rutherford with his attack published in *Nature*.

PhD thesis, Caltech August 1927 [22 pages]: http://thesis.library.caltech.edu/843/1/Thomassen_l_1927.pdf

Unstable $_{82}Pb^{210}$
Half-life = ~22.2 years

Lead

Alpha decay

Mercury

Unstable $_{80}Hg^{206}$
Half-life = ~8.2 minutes

Version of his thesis published in peer-reviewed journal as:

“Transmutation of elements”
L. Thomassen
***Physical Review* 33 pp. 229 - 238 (1929)**

http://authors.library.caltech.edu/2524/1/THOpr29.pdf

Comment re thesis:

Please note Thomassen’s frequent complaints about experimentalists having great difficulty in repeating their results in transmutation experiments; does that sort of complaint sound familiar *a la* Pons & Fleischmann?

See Lattice SlideShare document discussing this work:

http://www.slideshare.net/lewisglarsen/lattice-energy-llcaddendum-to-may-19-2012-technical-overview1927-caltech-experimentsmay-26-2012

Unstable $_{83}Bi^{210}$
Half-life = ~5 days

Bismuth

Alpha decay

Thallium

Unstable $_{81}Tl^{206}$
Half-life = ~4.2 minutes

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Historical perspective: over 100 years of data

1932: Chadwick confirms existence of Rutherford's predicted neutron

Neutral nuclear particle had been boldly conjectured by Rutherford back in 1920

> **"It is evident that we must either relinquish the application of the conservation of energy and momentum in these collisions or adopt another hypothesis about the nature of the radiation. If we suppose that the radiation is not a quantum radiation, but consists of particles of mass very nearly equal to that of the proton, all the difficulties connected with the collisions disappear, both with regard to their frequency and to the energy transfer to different masses. In order to explain the great penetrating power of the radiation we must further assume that the particle has no net charge. We may suppose it to consist of a proton and an electron in close combination, the 'neutron' as discussed by Rutherford in his Bakerian Lecture of 1920."**

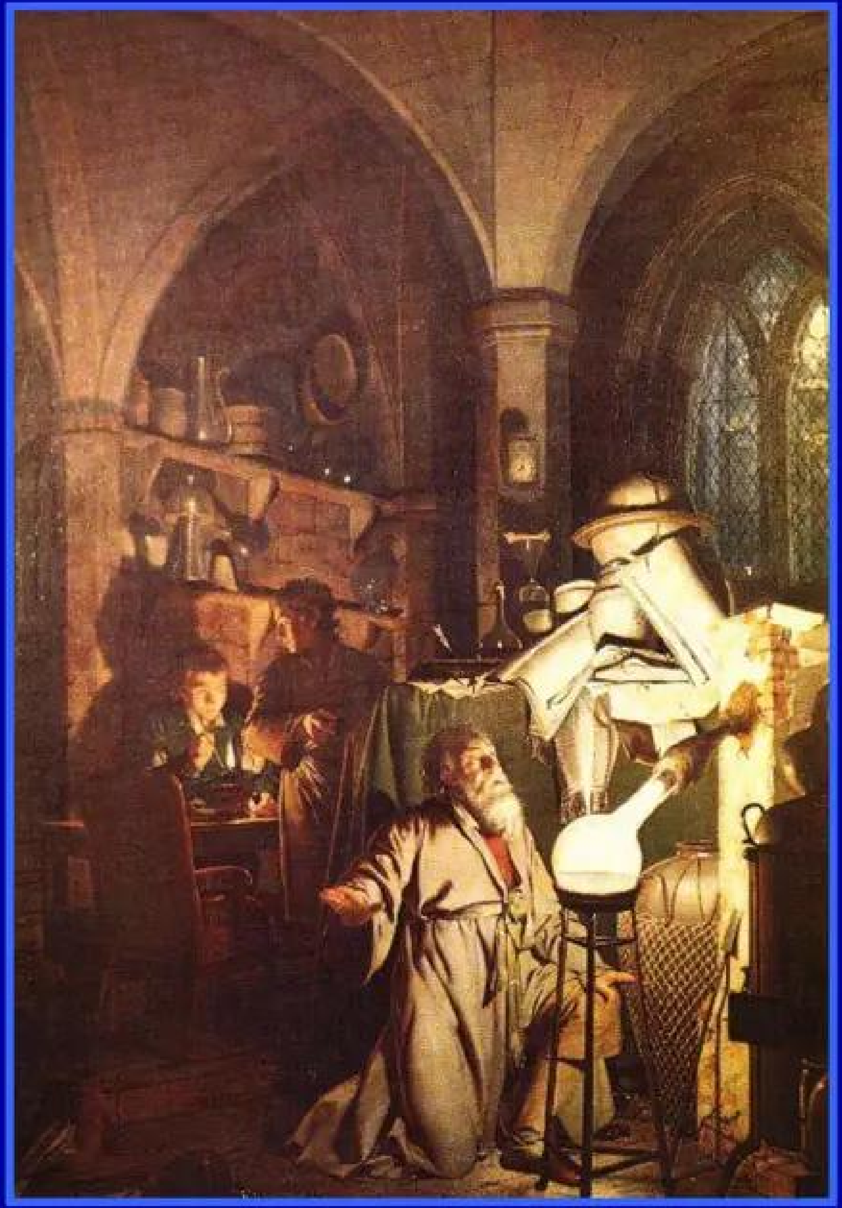
Above quoted from paper cited below; received Nobel Prize in physics for this work in 1936

"The existence of a neutron"
J. Chadwick
Proc. Roy. Soc. **A 136 pp. 692 - 708** (1932)

http://rspa.royalsocietypublishing.org/content/136/830/692.full.pdf

Quoting further:

> **"The properties of penetrating radiation emitted from Beryllium (and Boron) when bombarded by the α-particles of Polonium have been examined. It is concluded that the radiation consists, not of quanta as hitherto supposed, but of neutrons, particles of mass 1, and charge 0. Evidence is given to show that the mass of the neutron is probably between 1.005 and 1.008 … Although there is certain evidence for the emission of neutrons only in two cases of nuclear transformations, we must nevertheless suppose that the neutron is a common constituent of atomic nuclei … It is … possible to suppose that the neutron is an elementary particle. This view has little to recommend it at present …"**



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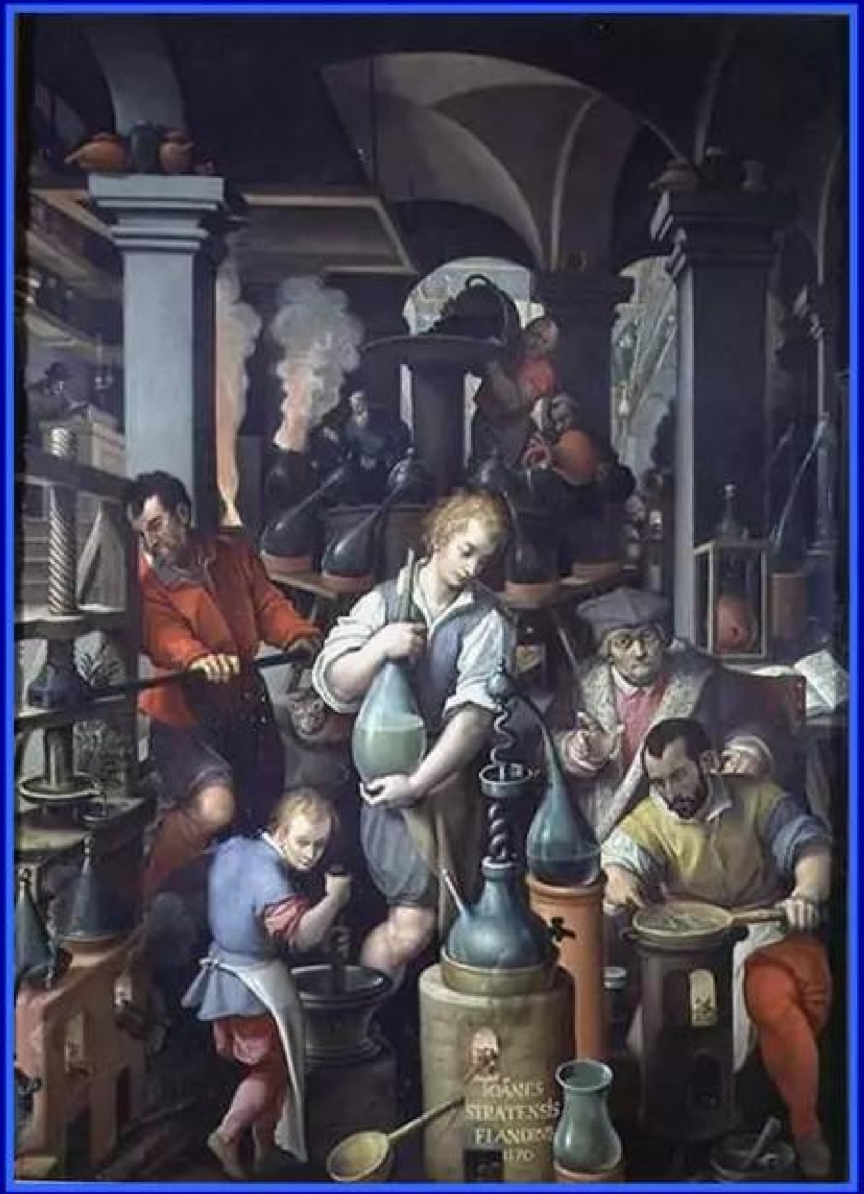
Historical perspective: over 100 years of data

1933: at his pinnacle, Rutherford dismisses commercial transmutation

“Anyone who expects a source of power from the transformation of the atom is talking moonshine.”

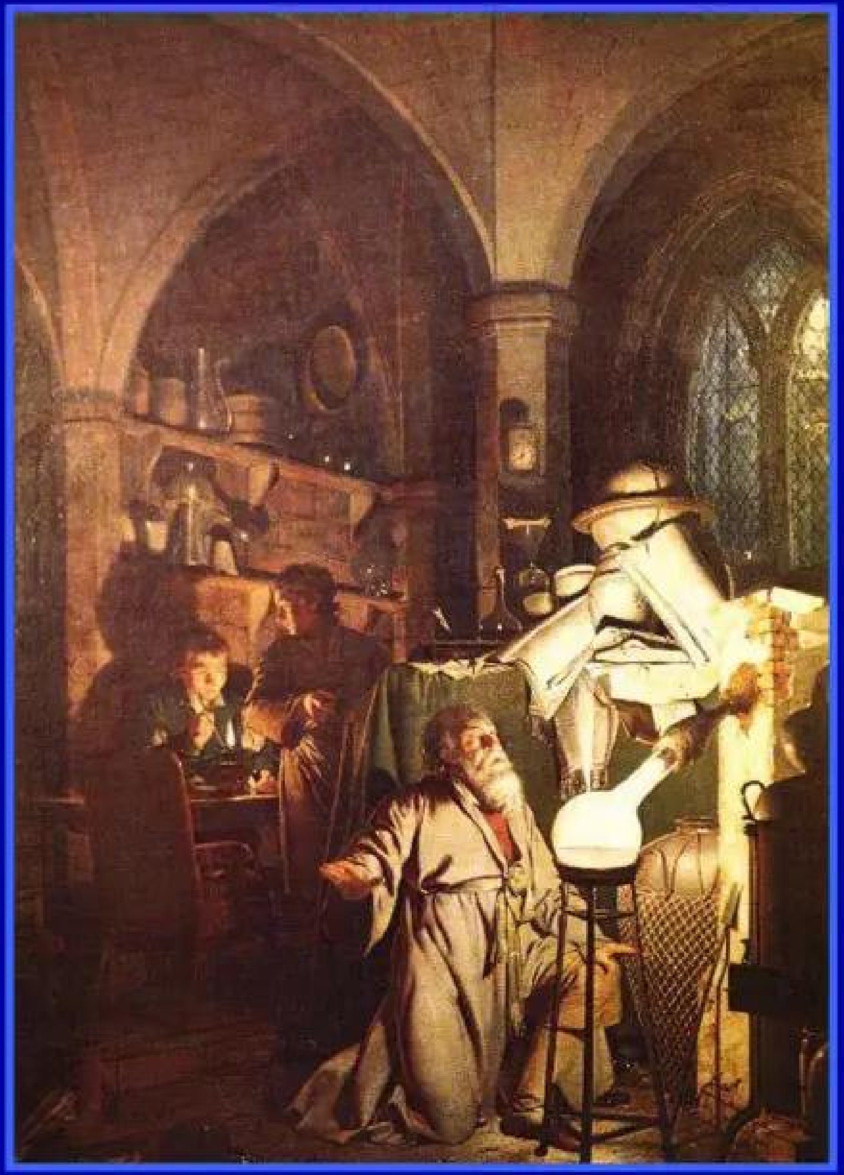
Variations of this comment made many times by Rutherford during 1930s; died suddenly in 1937 at age 66

Epilogue: fission discovered (1939); first use of atomic weapons (1945); first commercial reactor (1955)



“We might in these processes obtain very much more energy than the proton supplied, but on the average we could not expect to obtain energy in this way. It was a very poor and inefficient way of producing energy, and anyone who looked for a source of power in the transformation of the atoms was talking moonshine. But the subject was scientifically interesting because it gave insight into the atoms.”

***The London Times*, Sept. 12, 1933, quoted from talk given by Rutherford at a meeting of the British Association for the Advancement of Science**



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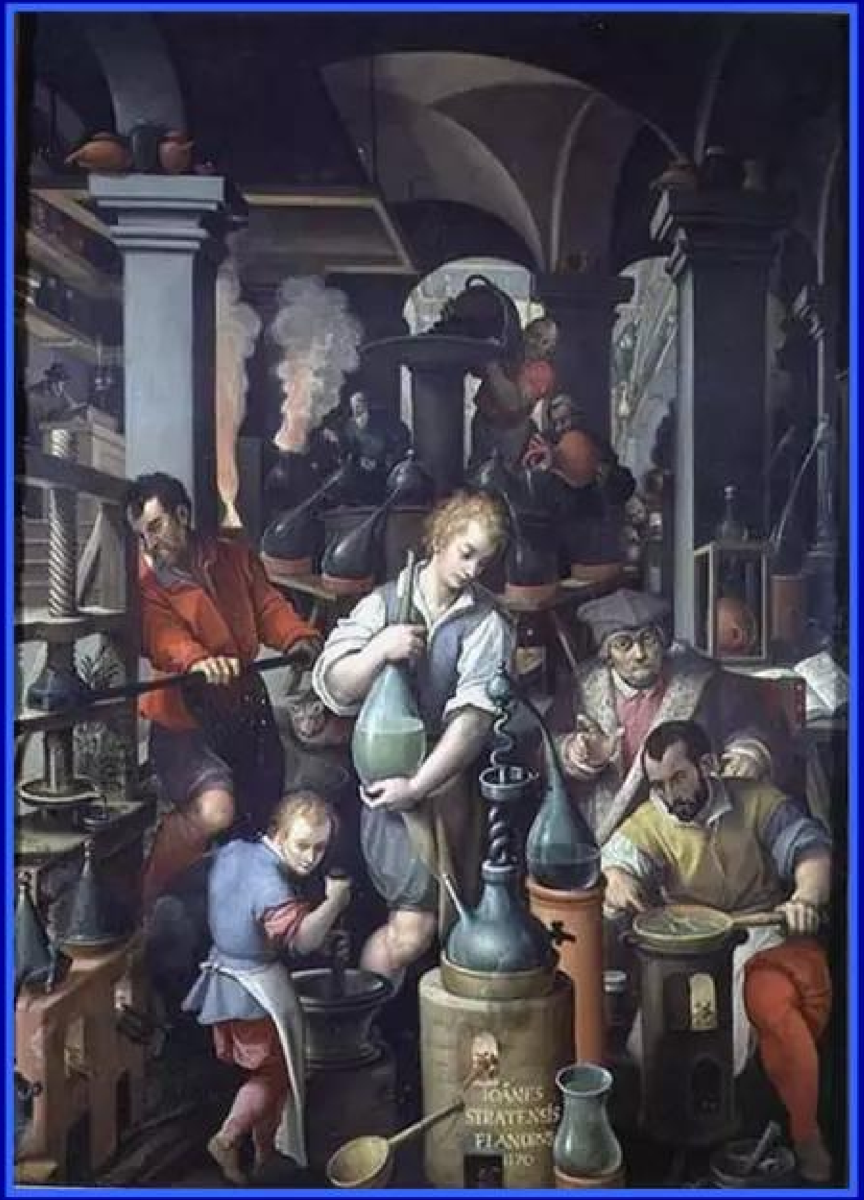
Historical perspective: over 100 years of data

1934: Fermi published beta decay theory in which neutrinos are invoked

“Versuch einer theorie der *β*-strahlen. I“

Googlish translation of German abstract: “A quantitative theory of *β*-decay is proposed, in which one assumes the existence of the neutrino, and treated the emission of electrons and neutrinos from a core in *β*-decay with a similar method as in the emission of a photon from an excited atom of radiation theory. Formulas for the service life and for the shape of the emitted *β*-continuous radiation spectrum can be derived and compared with observations.”

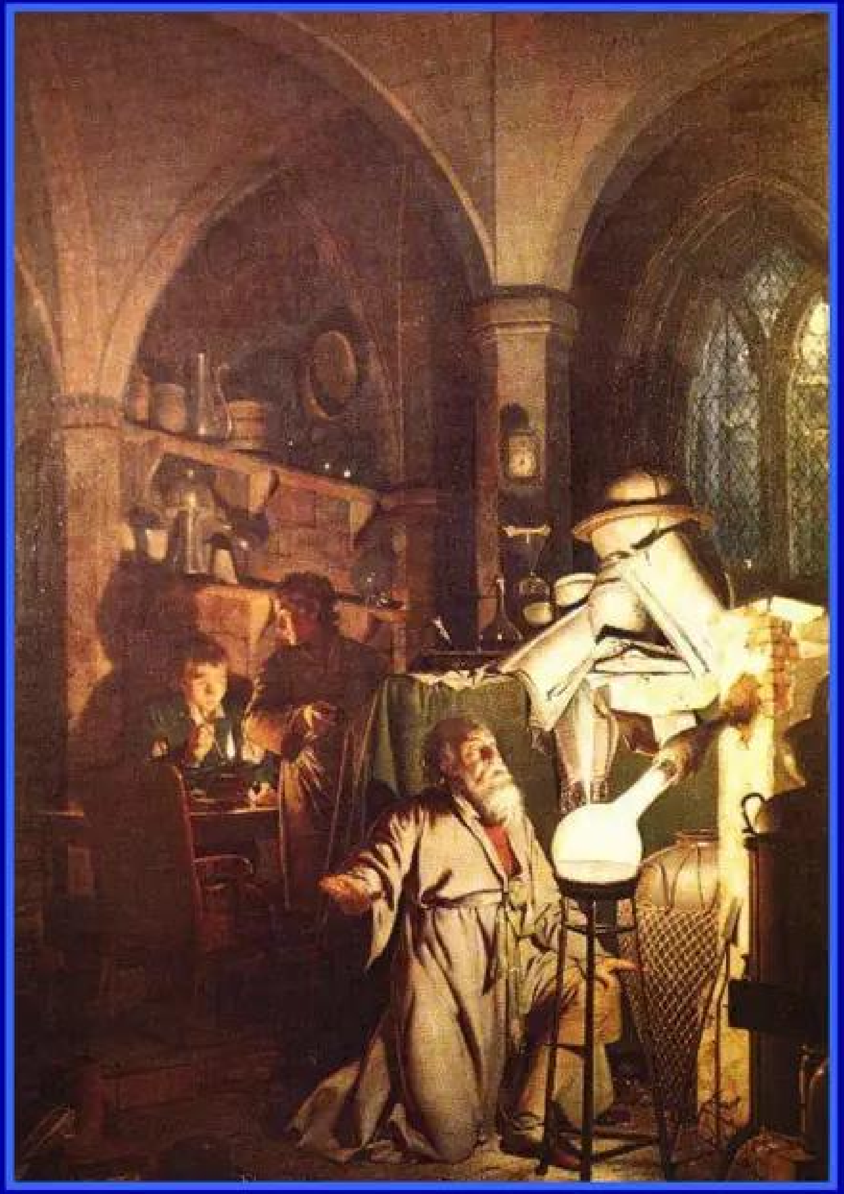
Epilogue: Salam, Glashow, and Weinberg published electroweak theory (1960s); eventually confirmed experimentally (1980s)



“Versuch einer Theorie der *β*-Strahlen. I“
Enrico Fermi
***Zeitschrift für Physik* 88 pp. 161-177 (1934)**

In 1938, he received Nobel prize in physics for work on induced radioactivity & discovery of transuranic elements

Comment: in Fermi’s theory, the neutron conceptually became an elementary particle (instead of an electron tightly-bound to a proton located inside a nucleus proper). The idea of an inverse beta decay electron capture $e + p \rightarrow n + \nu$ process occurring outside of a nucleus in Nature was first discussed by Fred Hoyle (*MNRAS* 106 pp. 343 - 383, 1946) in connection with theoretical work on collapsing stars. Fast forward to 1990s: several LENR researchers (e.g., Mizuno) speculated that $e + p$ neutron production could be occurring in electrolytic chemical cells. In a 2005 arXiv preprint, Widom & Larsen published LENR theory that integrated many-body collective effects with modern electroweak theory under umbrella of the Standard Model



Historical perspective: over 100 years of data

1935 to 1980s: most experimental work on LENR transmutations stops

Comment: it is very puzzling why this seemingly fruitful line of inquiry involving electric-arc-driven transmutations seems to have more-or-less died-out worldwide by the time Chadwick experimentally verified the Rutherford neutron's existence in 1932. After that date, only a handful of researchers such as Fritz Paneth continued the work. Oddly, it also does not appear that anyone else ever tried to exactly duplicate Nagaoka's astounding experiments.

However, at around that time there were very well-publicized failures to replicate Miethe & Stammreich's Gold experiments that were extensively chronicled in *Scientific American*. Interestingly, Miethe's experimental apparatus consisted of Mercury arc lamps with Tungsten electrodes inside well-evacuated quartz tubes; no transformer oil was present in those electric arc experiments. In hindsight, perhaps Nagaoka's decision to use oil was exceedingly fortuitous: by arcing in transformer oil, he inadvertently guaranteed that his experimental apparatus contained huge quantities of hydrogen (protons) for making neutrons via LENRs.

?

What happened during this time? Why did
electric arc transmutation research just stop?
Was it problems with reproducibility?

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Historical perspective: over 100 years of data

1989: Pons & Fleischmann claim “cold fusion” occurs in chemical cells

D+D fusion theory was wrong; excess heat results were irreproducible back then

Tragic outcome was very similar to Wendt & Irion’s controversy with Rutherford back in 1922 - 23

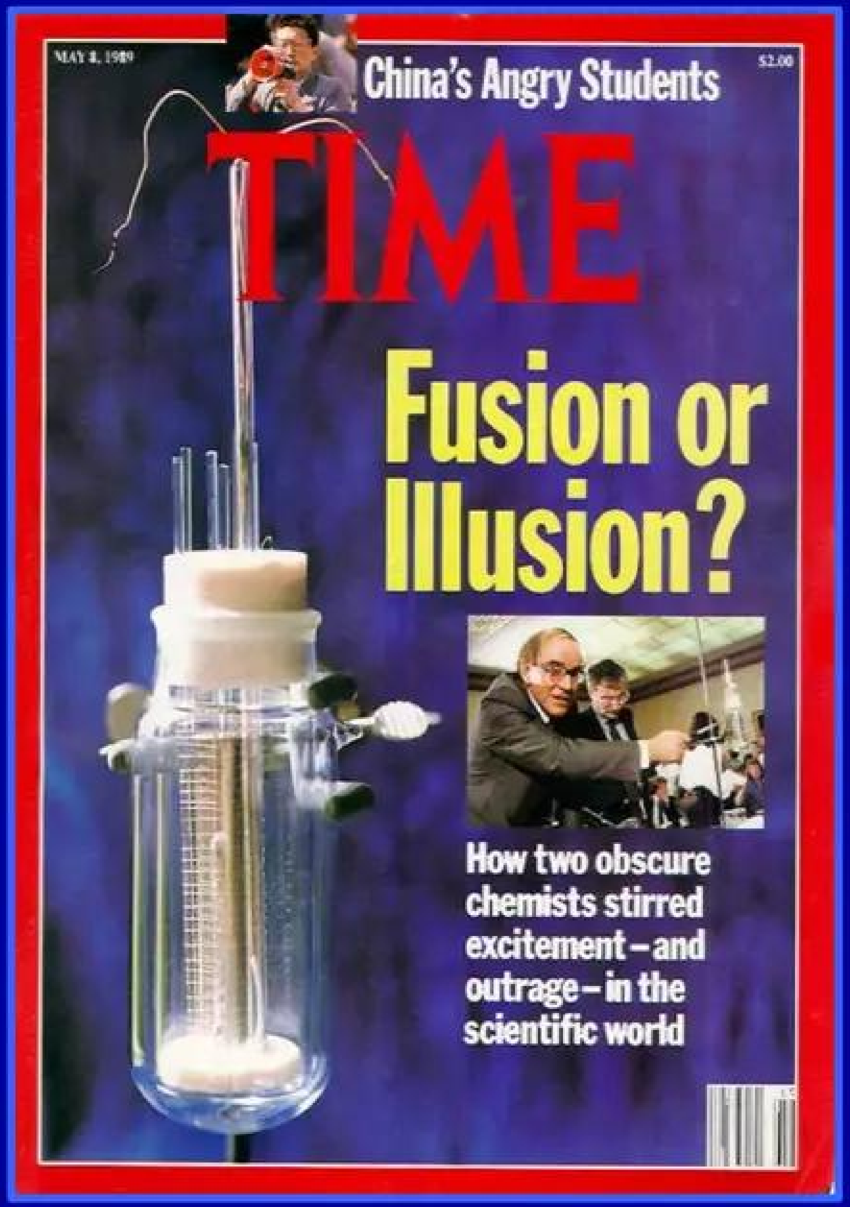
“Electrochemically induced nuclear fusion of deuterium”

Martin Fleischmann and Stanley Pons

Journal of Electroanalytical Chemistry **261 pp. 301 - 309 (1989)**


AP/file

Comment: unfortunately for Pons & Fleischmann, their claimed excess heat production effects were very poorly reproducible in 1989-1990 because they were completely wrong about their D+D fusion hypothesis and had no knowledge whatsoever of what are now called the fields of nanotechnology and plasmonics. Indeed, certain recent technical knowledge derived from nanotechnology, plasmonics, and advanced materials science that is crucial to being able to fabricate reproducible, well-performing LENR devices did not even exist in 1989, or even in the mid- to late 1990s. In our opinion, there is no way condensed matter LENRs could have been truly experimentally reproducible prior to the past several years. Commercialization of technology should now be feasible with the help of new Widom-Larsen theory and nanotech.



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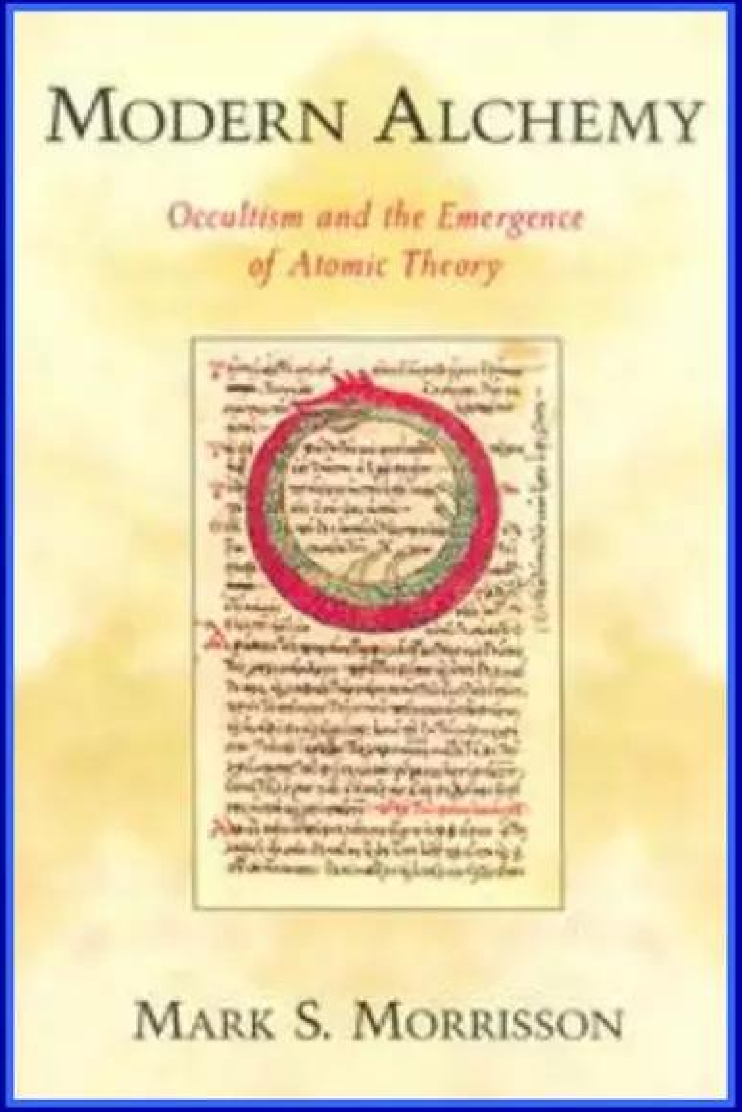
Historical perspective: over 100 years of data

1990s: Huizenga personally believed that LENRs were very dubious

Skepticism is reminiscent of Rutherford's dismissal of nuclear power in 1930s

"Plus ça change, plus c'est la même chose."

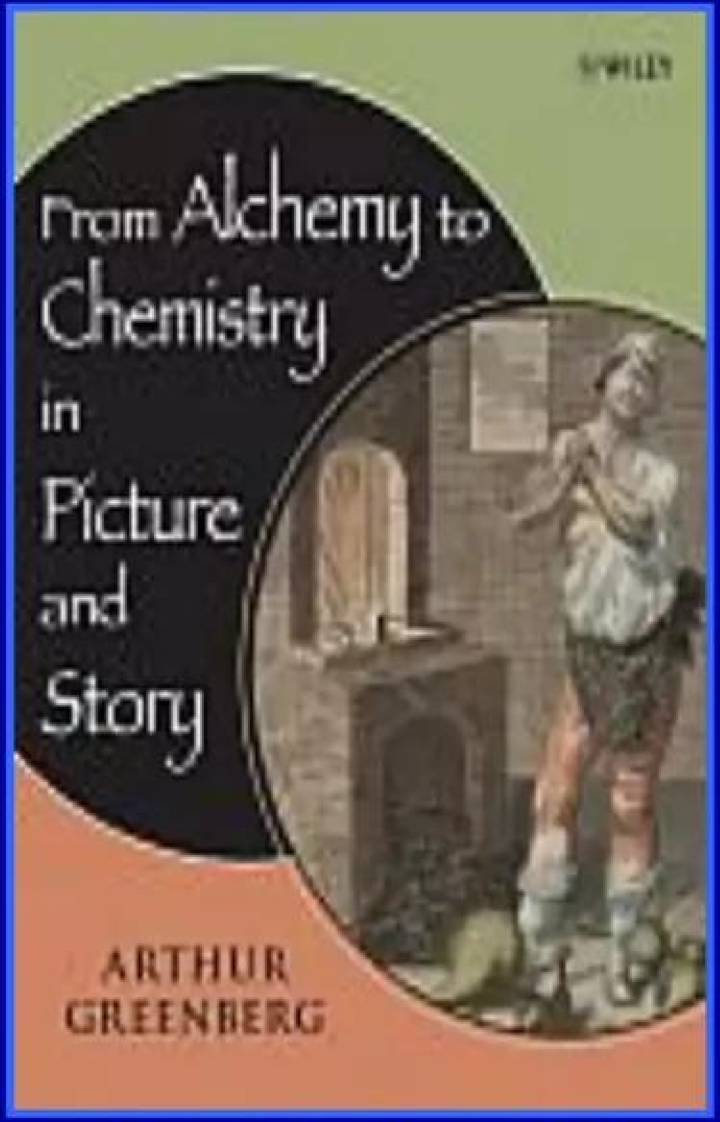
Epigram by Jean-Baptiste Alphonse Karr in the January 1849 issue of his journal "*Les Guêpes*" (The Wasps)



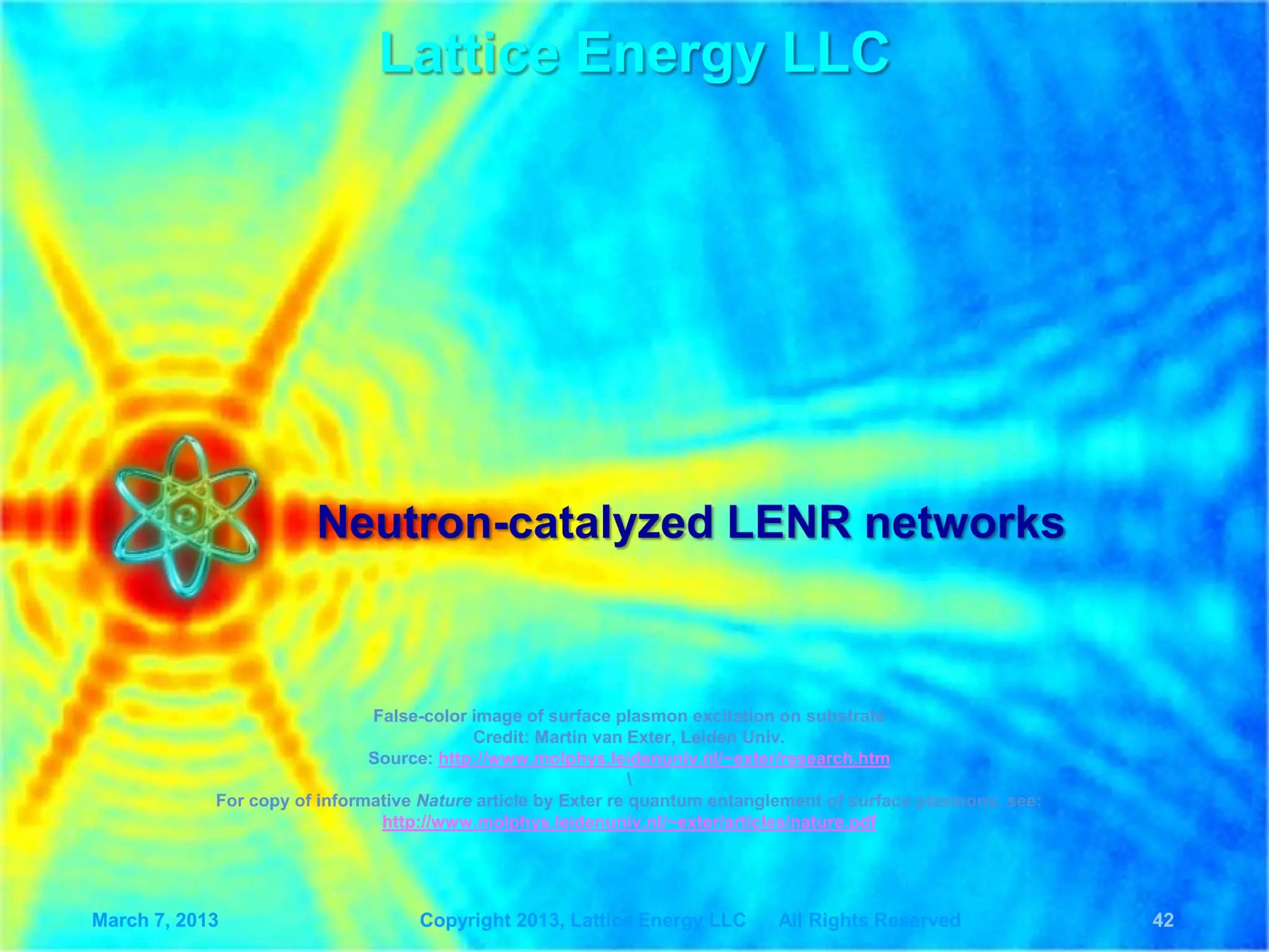
Oxford University Press (2007)

"The idea of producing useful energy from room temperature nuclear reactions is an aberration."

Prof. John Huizenga, well-respected chemist and physicist, referring to "cold fusion" in his 1993 book, "Cold fusion --- The scientific fiasco of the century"



Wiley – Interscience (2007)



Neutron-catalyzed LENR networks

False-color image of surface plasmon excitation on substrate
Credit: Martin van Exter, Leiden Univ.
Source: http://www.molphys.leidenuniv.nl/~exter/research.htm
\
For copy of informative *Nature* article by Exter re quantum entanglement of surface plasmons, see:
http://www.molphys.leidenuniv.nl/~exter/articles/nature.pdf

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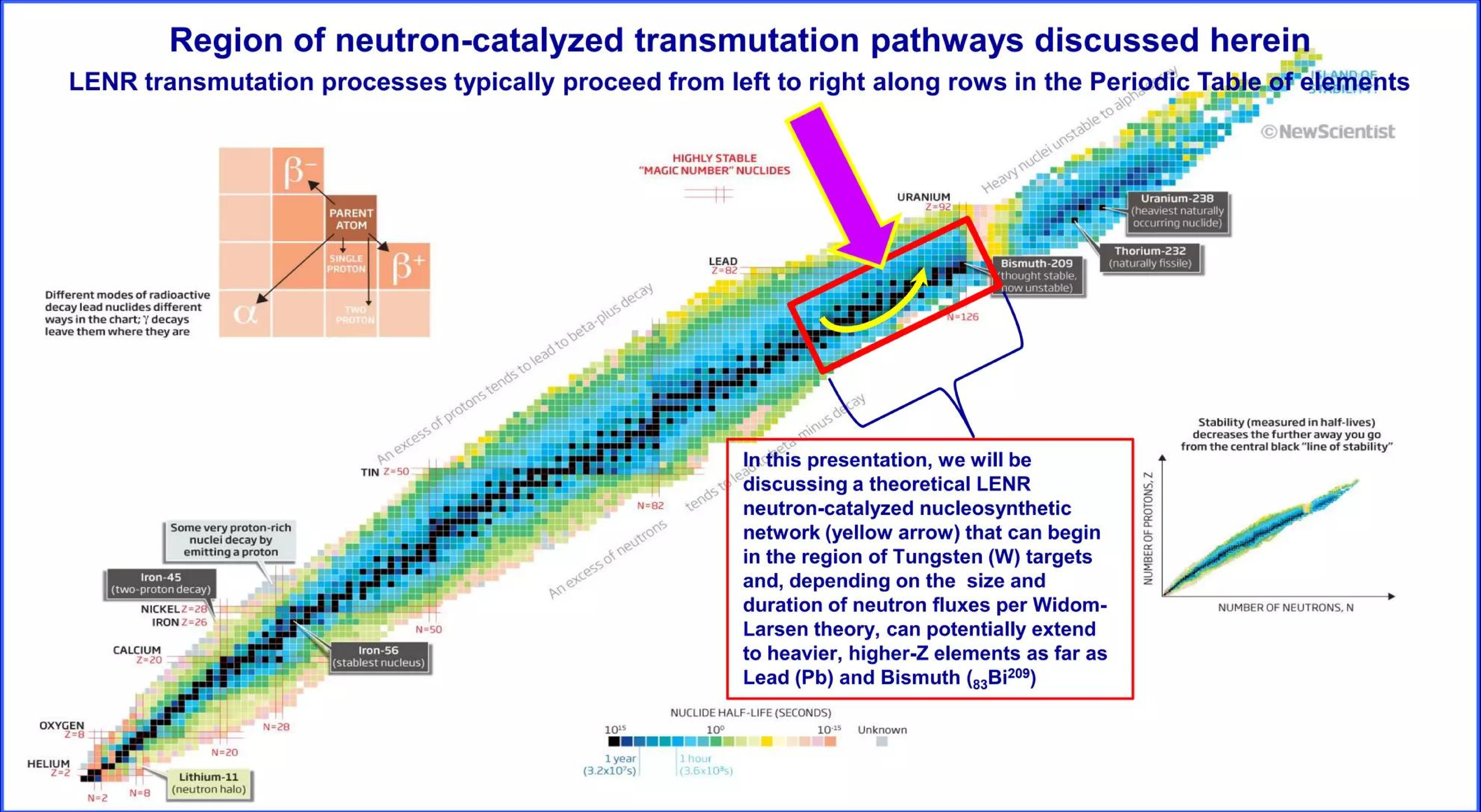
Neutron-catalyzed LENR networks

Map of all presently known stable and unstable isotopes of elements



Region of neutron-catalyzed transmutation pathways discussed herein

LENR transmutation processes typically proceed from left to right along rows in the Periodic Table of elements

In this presentation, we will be discussing a theoretical LENR neutron-catalyzed nucleosynthetic network (yellow arrow) that can begin in the region of Tungsten (W) targets and, depending on the size and duration of neutron fluxes per Widom-Larsen theory, can potentially extend to heavier, higher-Z elements as far as Lead (Pb) and Bismuth ($_{83}Bi^{209}$)

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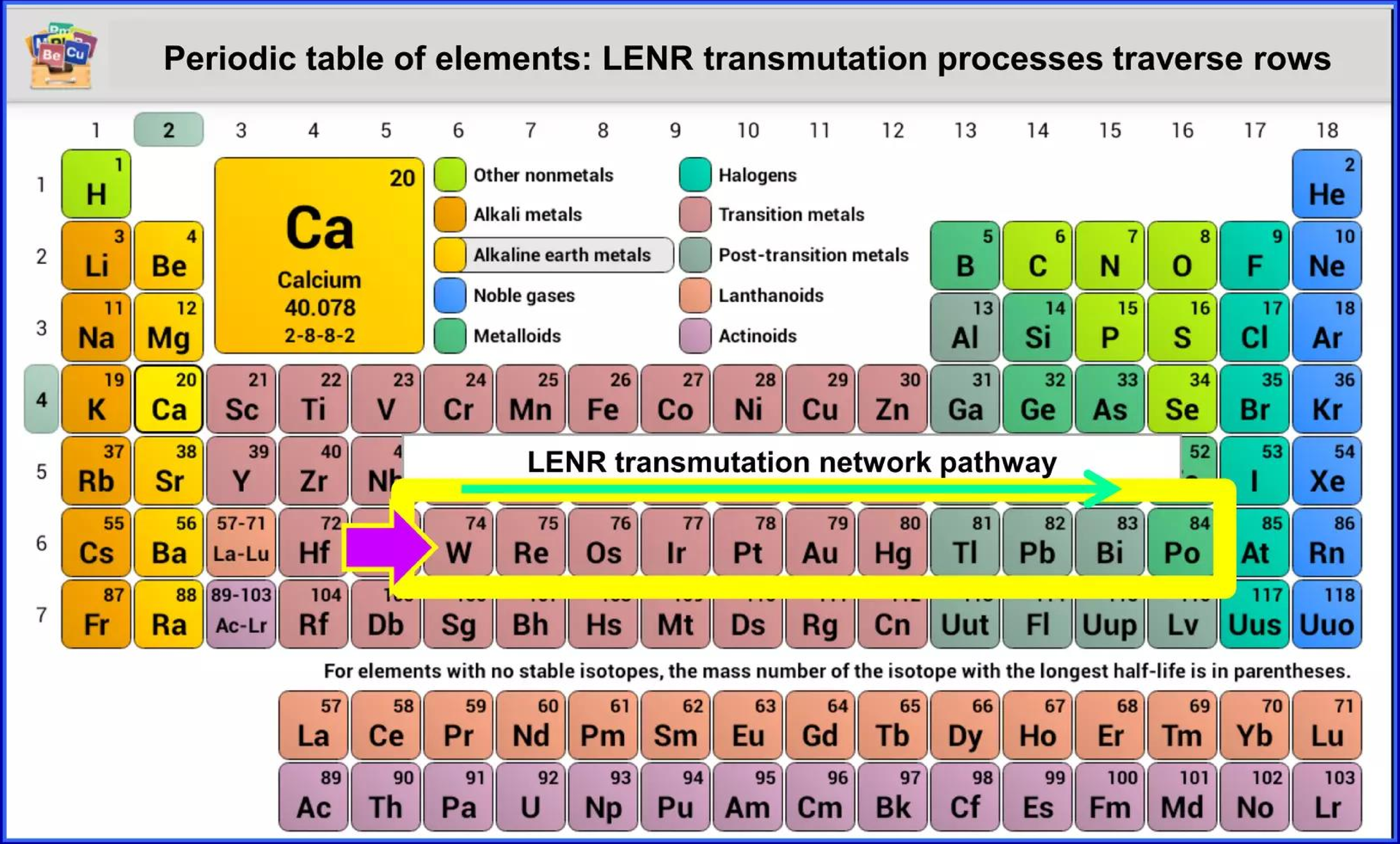
Neutron-catalyzed LENR networks

Starting with Tungsten targets can reach Lead (Pb) and Bismuth ($_{83}Bi^{209}$)



Periodic table of elements: LENR transmutation processes traverse rows

LENR transmutation network pathway

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

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Neutron-catalyzed LENR networks

Example: network makes Platinum, Gold, Mercury, Lead, and Bismuth

- ✓ We will now examine a hypothetical LENR transmutation network that can begin with neutron captures on Tungsten (W) as well as other intermediate targets
- ✓ Explanatory legend for network diagrams appears on the next slide
- ✓ ${}_{74}W^{180}$-seed network includes Mercury (Hg); if sufficiently high neutron fluxes are maintained for enough time, can even reach Bismuth (Bi) under optimal conditions
- ✓ While unstable intermediate network products undergo nuclear decays, their half-lives are generally short (especially those that are more neutron-rich); this network does not produce significant amounts of dangerous long-lived radioactive isotopes
- ✓ According to the WLT, in condensed matter systems LENRs occur in many tiny nm- to micron-scale surface sites or patches that only exist for several hundred nanoseconds before they 'die'; such sites can form and re-form spontaneously
- ✓ Need input energy to make ultra cold neutrons that catalyze LENR transmutations
- ✓ Herein, we will discuss new Hg isotopic data of Mead *et al*. indicating that portions of this nucleosynthetic network may be occurring inside compact fluorescent lights

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Neutron-catalyzed LENR networks

Example: network makes Platinum, Gold, Mercury, Lead, and Bismuth

Legend:

Neutron capture and nuclear decay processes:

ULM neutron captures proceed from left to right except for upper-left corner; Q-value of capture reaction (MeV) in green either above or below horizontal arrow. →

Beta$^-$ (β^-) decays proceed from top to bottom; denoted with bright blue vertical arrow ↓ pointing down with Q-value (MeV) in blue either to left or right; beta$^+$ (β^+) decays are denoted with yellow arrow pointing upward to row above ↑

Alpha decays, indicated with orange arrows, proceed mostly from right to left at an angle with Q-value (MeV) shown in orange located on either side of the process arrow. ↖

Electron captures (e.c.) indicated by purple vertical arrow; Q-value (MeV) to left or right. ↑

Note: to reduce visual clutter in the network diagram, gamma emissions (converted to infrared photons by heavy e^{-*} electrons) are not shown; similarly, except where specifically listed because a given branch cross-section is significant, beta-delayed decays also generally not shown; BR means “branching ratio” if >1 decay alternative

Color coded half-lives:

When known, half-lives shown as “HL = xx”. Stable and quasi-stable isotopes (i.e., those with half-lives > or equal to 10^7 years) indicated by green boxes; isotopes with half-lives < 10^7 but > than or equal to 10^3 years indicated by light blue; those with half-lives < than 10^3 years but > or equal to 1 day are denoted by purplish boxes; half-lives of < 1 day in yellow; with regard to half-life, notation “? nm” means isotope has been verified by HL has not been measured

Measured natural terrestrial abundances for stable isotopes:

Indicated with % symbol; note that $_{83}$Bi^{209} = 100% (essentially ~stable with half-life = 1.9×10^{19} yrs); $_{82}$Pb-205 ~stable with HL= 1.5×10^7 yrs

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Neutron-catalyzed LENR networks

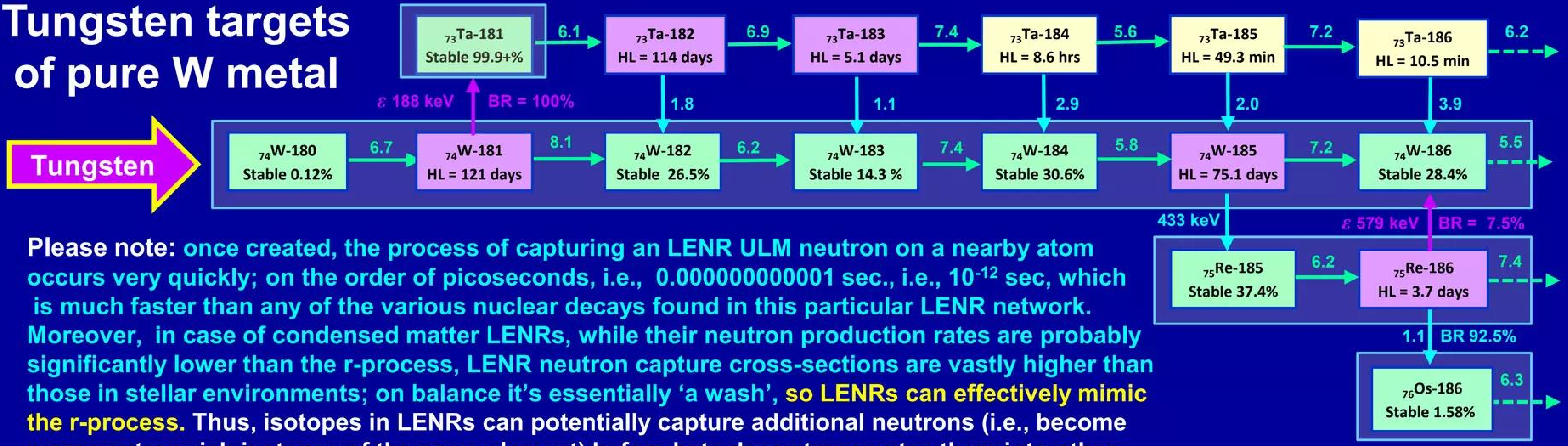
Example: network makes Platinum, Gold, Mercury, Lead, and Bismuth

Increasing values of A

Network may potentially continue upward to even higher values of A;
This depends on ULM neutron flux in cm^2/sec

Start with stable Tungsten targets of pure W metal

Alternatively, one could start with $_{73}$Ta^{181} target



$_{73}$Ta-181 Stable 99.9+% → 6.1 → $_{73}$Ta-182 HL = 114 days → 6.9 → $_{73}$Ta-183 HL = 5.1 days → 7.4 → $_{73}$Ta-184 HL = 8.6 hrs → 5.6 → $_{73}$Ta-185 HL = 49.3 min → 7.2 → $_{73}$Ta-186 HL = 10.5 min → 6.2

ε 188 keV BR = 100%

1.8 1.1 2.9 2.0 3.9

Tungsten

$_{74}$W-180 Stable 0.12% → 6.7 → $_{74}$W-181 HL = 121 days → 8.1 → $_{74}$W-182 Stable 26.5% → 6.2 → $_{74}$W-183 Stable 14.3 % → 7.4 → $_{74}$W-184 Stable 30.6% → 5.8 → $_{74}$W-185 HL = 75.1 days → 7.2 → $_{74}$W-186 Stable 28.4% → 5.5

433 keV

ε 579 keV BR = 7.5%

$_{75}$Re-185 Stable 37.4% → 6.2 → $_{75}$Re-186 HL = 3.7 days → 7.4

1.1 BR 92.5%

$_{76}$Os-186 Stable 1.58% → 6.3

Increasing values of Z

Please note: once created, the process of capturing an LENR ULM neutron on a nearby atom occurs very quickly; on the order of picoseconds, i.e., 0.000000000001 sec., i.e., 10^{-12} sec, which is much faster than any of the various nuclear decays found in this particular LENR network. Moreover, in case of condensed matter LENRs, while their neutron production rates are probably significantly lower than the r-process, LENR neutron capture cross-sections are vastly higher than those in stellar environments; on balance it's essentially 'a wash', so LENRs can effectively mimic the r-process. Thus, isotopes in LENRs can potentially capture additional neutrons (i.e., become more neutron-rich isotopes of the same element) before beta decay transmutes them into other higher-Z elements found in the Periodic Table. This is why the 'hot' astrophysical r-process can make heavier elements than the s-process (i.e., go beyond Bismuth): with much higher produced neutron fluxes, the r-process can successfully traverse and bridge key regions of very short-lived isotopes that are found in ultra-neutron-rich, high-Z reaches of vast nuclear isotopic landscape

It should also be noted that all of the many atoms located within a 3-D region of space that encompasses a given ULM neutron's spatially extended DeBroglie wave function (whose dimensions can range from 2 nm to 100 microns) will compete with each other to capture such neutrons. ULM neutron capture is thus a decidedly many-body scattering process, not few-body scattering such as that which characterizes capture of neutrons at thermal energies in condensed matter in which the DeBroglie wave function of a thermal neutron is on the order of ~ 2 Angstroms. This explains why vast majority of produced neutrons are captured locally and are only rarely detected at any energies during course of LENR experiments; it also clearly explains why human-lethal MeV-energy neutron fluxes are characteristically not produced in condensed matter LENR systems.

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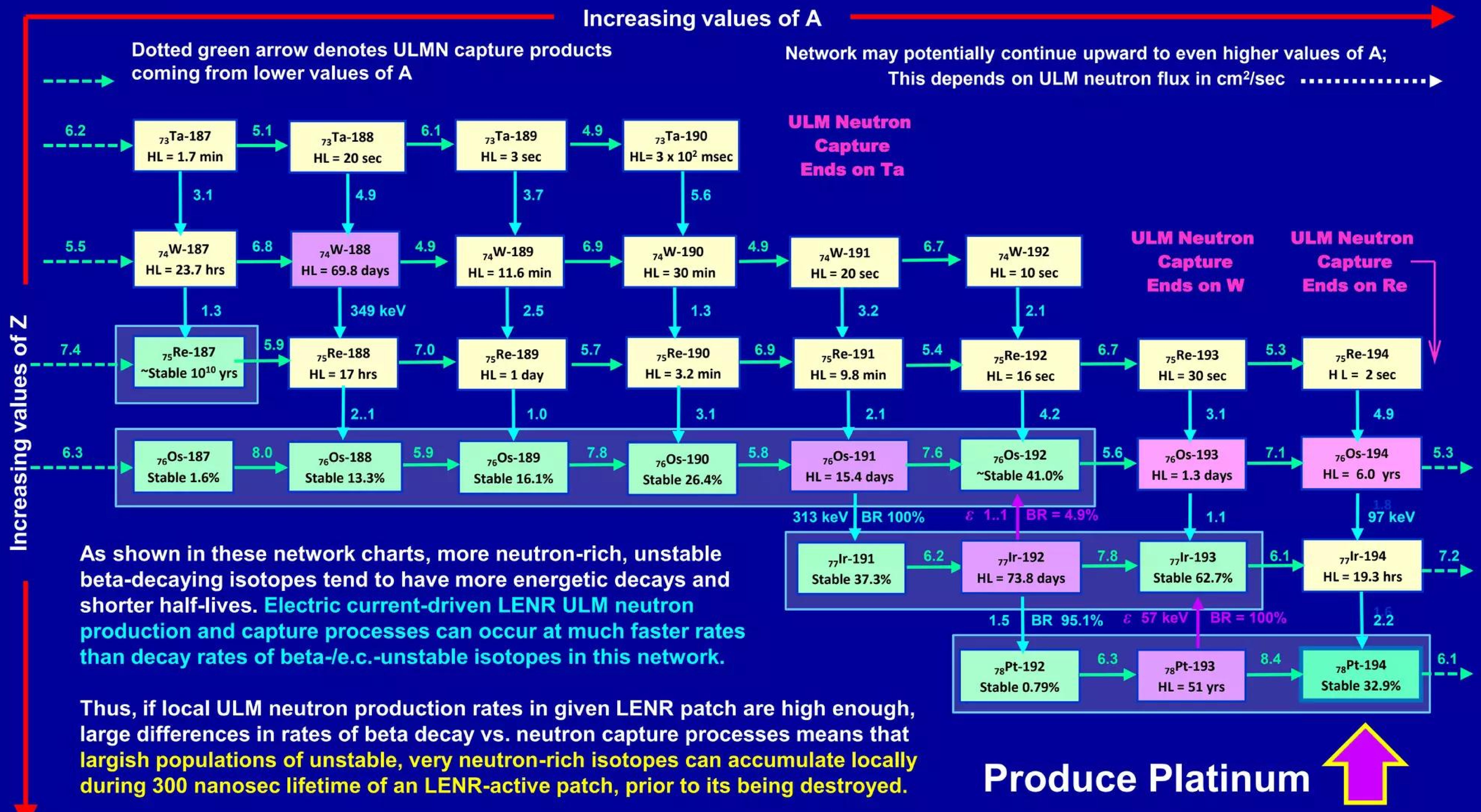
Neutron-catalyzed LENR networks

Example: network makes Platinum, Gold, Mercury, Lead, and Bismuth



Increasing values of A

Increasing values of Z

Dotted green arrow denotes ULMN capture products coming from lower values of A

Network may potentially continue upward to even higher values of A;
This depends on ULM neutron flux in cm^2/sec

6.2 → $_{73}$Ta-187 HL = 1.7 min → 5.1 → $_{73}$Ta-188 HL = 20 sec → 6.1 → $_{73}$Ta-189 HL = 3 sec → 4.9 → $_{73}$Ta-190 HL= 3 x 10^2 msec

ULM Neutron Capture Ends on Ta

3.1 | 4.9 | 3.7 | 5.6

5.5 → $_{74}$W-187 HL = 23.7 hrs → 6.8 → $_{74}$W-188 HL = 69.8 days → 4.9 → $_{74}$W-189 HL = 11.6 min → 6.9 → $_{74}$W-190 HL = 30 min → 4.9 → $_{74}$W-191 HL = 20 sec → 6.7 → $_{74}$W-192 HL = 10 sec

ULM Neutron Capture Ends on W

ULM Neutron Capture Ends on Re

1.3 | 349 keV | 2.5 | 1.3 | 3.2 | 2.1

7.4 → $_{75}$Re-187 ~Stable 10^{10} yrs → 5.9 → $_{75}$Re-188 HL = 17 hrs → 7.0 → $_{75}$Re-189 HL = 1 day → 5.7 → $_{75}$Re-190 HL = 3.2 min → 6.9 → $_{75}$Re-191 HL = 9.8 min → 5.4 → $_{75}$Re-192 HL = 16 sec → 6.7 → $_{75}$Re-193 HL = 30 sec → 5.3 → $_{75}$Re-194 H L = 2 sec

2..1 | 1.0 | 3.1 | 2.1 | 4.2 | 3.1 | 4.9

6.3 → $_{76}$Os-187 Stable 1.6% → 8.0 → $_{76}$Os-188 Stable 13.3% → 5.9 → $_{76}$Os-189 Stable 16.1% → 7.8 → $_{76}$Os-190 Stable 26.4% → 5.8 → $_{76}$Os-191 HL = 15.4 days → 7.6 → $_{76}$Os-192 ~Stable 41.0% → 5.6 → $_{76}$Os-193 HL = 1.3 days → 7.1 → $_{76}$Os-194 HL = 6.0 yrs → 5.3

313 keV BR 100% | ε 1..1 BR = 4.9% | 1.1 | 1.8 97 keV

$_{77}$Ir-191 Stable 37.3% → 6.2 → $_{77}$Ir-192 HL = 73.8 days → 7.8 → $_{77}$Ir-193 Stable 62.7% → 6.1 → $_{77}$Ir-194 HL = 19.3 hrs → 7.2

1.5 BR 95.1% | ε 57 keV BR = 100% | 1.6 2.2

$_{78}$Pt-192 Stable 0.79% → 6.3 → $_{78}$Pt-193 HL = 51 yrs → 8.4 → $_{78}$Pt-194 Stable 32.9% → 6.1

Produce Platinum

As shown in these network charts, more neutron-rich, unstable beta-decaying isotopes tend to have more energetic decays and shorter half-lives. Electric current-driven LENR ULM neutron production and capture processes can occur at much faster rates than decay rates of beta-/e.c.-unstable isotopes in this network.

Thus, if local ULM neutron production rates in given LENR patch are high enough, large differences in rates of beta decay vs. neutron capture processes means that largish populations of unstable, very neutron-rich isotopes can accumulate locally during 300 nanosec lifetime of an LENR-active patch, prior to its being destroyed.

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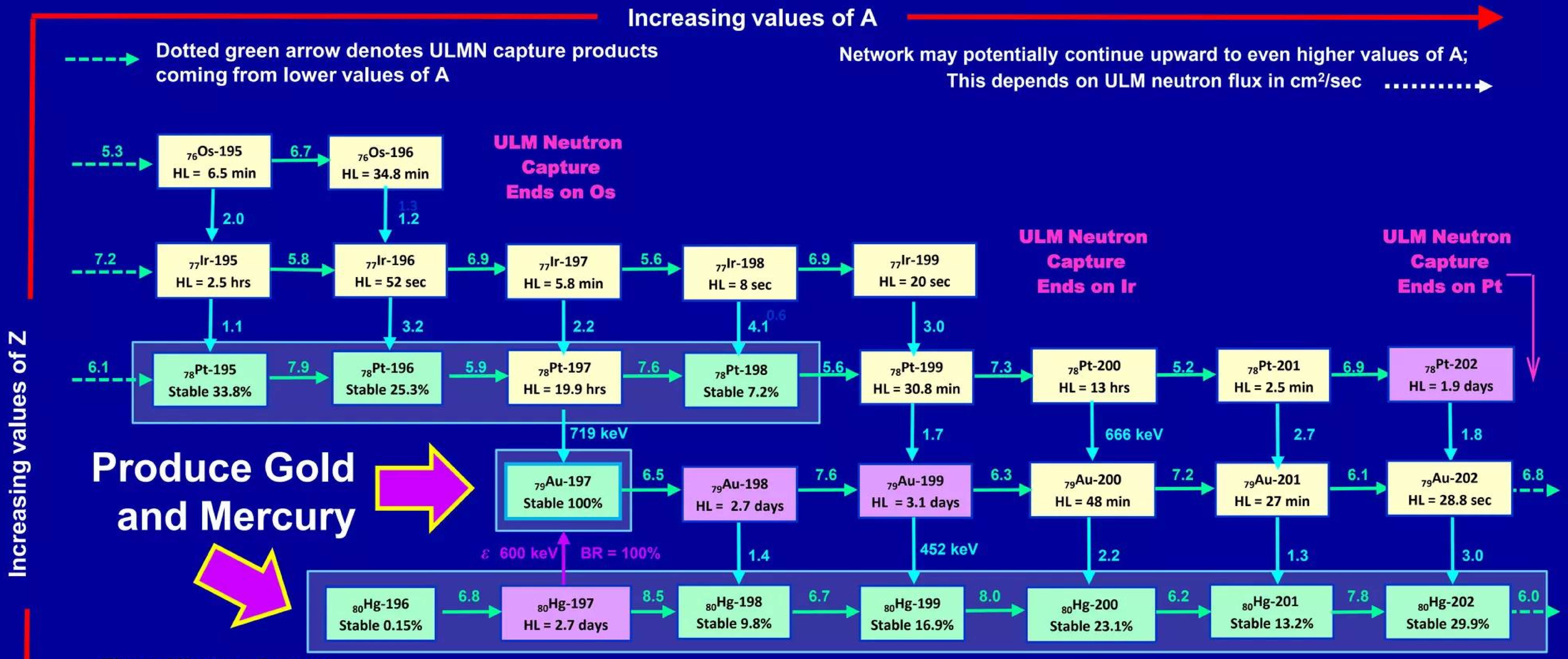
Neutron-catalyzed LENR networks

Example: network makes Platinum, Gold, Mercury, Lead, and Bismuth



Increasing values of A

Increasing values of Z

Dotted green arrow denotes ULMN capture products coming from lower values of A

Network may potentially continue upward to even higher values of A; This depends on ULM neutron flux in cm^2/sec

ULM Neutron Capture Ends on Os

ULM Neutron Capture Ends on Ir

ULM Neutron Capture Ends on Pt

5.3 → $_{76}$Os-195 HL = 6.5 min → 6.7 → $_{76}$Os-196 HL = 34.8 min

$_{76}$Os-195 ↓ 2.0; $_{76}$Os-196 ↓ 1.3 1.2

7.2 → $_{77}$Ir-195 HL = 2.5 hrs → 5.8 → $_{77}$Ir-196 HL = 52 sec → 6.9 → $_{77}$Ir-197 HL = 5.8 min → 5.6 → $_{77}$Ir-198 HL = 8 sec → 6.9 → $_{77}$Ir-199 HL = 20 sec

$_{77}$Ir-195 ↓ 1.1; $_{77}$Ir-196 ↓ 3.2; $_{77}$Ir-197 ↓ 2.2; $_{77}$Ir-198 ↓ 4.1 0.6; $_{77}$Ir-199 ↓ 3.0

6.1 → $_{78}$Pt-195 Stable 33.8% → 7.9 → $_{78}$Pt-196 Stable 25.3% → 5.9 → $_{78}$Pt-197 HL = 19.9 hrs → 7.6 → $_{78}$Pt-198 Stable 7.2% → 5.6 → $_{78}$Pt-199 HL = 30.8 min → 7.3 → $_{78}$Pt-200 HL = 13 hrs → 5.2 → $_{78}$Pt-201 HL = 2.5 min → 6.9 → $_{78}$Pt-202 HL = 1.9 days

$_{78}$Pt-197 ↓ 719 keV; $_{78}$Pt-199 ↓ 1.7; $_{78}$Pt-200 ↓ 666 keV; $_{78}$Pt-201 ↓ 2.7; $_{78}$Pt-202 ↓ 1.8

Produce Gold and Mercury

$_{79}$Au-197 Stable 100% → 6.5 → $_{79}$Au-198 HL = 2.7 days → 7.6 → $_{79}$Au-199 HL = 3.1 days → 6.3 → $_{79}$Au-200 HL = 48 min → 7.2 → $_{79}$Au-201 HL = 27 min → 6.1 → $_{79}$Au-202 HL = 28.8 sec → 6.8 →

$_{80}$Hg-197 ↑ ε 600 keV BR = 100%; $_{79}$Au-198 ↓ 1.4; $_{79}$Au-199 ↓ 452 keV; $_{79}$Au-200 ↓ 2.2; $_{79}$Au-201 ↓ 1.3; $_{79}$Au-202 ↓ 3.0

$_{80}$Hg-196 Stable 0.15% → 6.8 → $_{80}$Hg-197 HL = 2.7 days → 8.5 → $_{80}$Hg-198 Stable 9.8% → 6.7 → $_{80}$Hg-199 Stable 16.9% → 8.0 → $_{80}$Hg-200 Stable 23.1% → 6.2 → $_{80}$Hg-201 Stable 13.2% → 7.8 → $_{80}$Hg-202 Stable 29.9% → 6.0 →

Thermal Neutron Capture Cross-section (barns)	105	not available	0.017	2.1 x 10^3	<60	<60	4.9

Please note that: Q-value for neutron capture on a given beta-unstable isotope is often larger than the Q-value for the alternative β^- decay pathway, so in addition to being a faster process than beta decay it can also be energetically more favorable. This can also contribute to creating fleeting yet substantial local populations of short-lived, neutron-rich isotopes. There is indirect experimental evidence that such neutron-rich isotopes can be produced in complex ULM neutron-catalyzed LENR nucleosynthetic (transmutation) networks that set-up and operate during brief lifetime of an LENR-active patch; see Carbon-seed network on Slides # 11 - 12 and esp. on Slide #55 in http://www.slideshare.net/lewisglarsen/lattice-energy-llctechnical-overviewcarbon-seed-lenr-networkssept-3-2009

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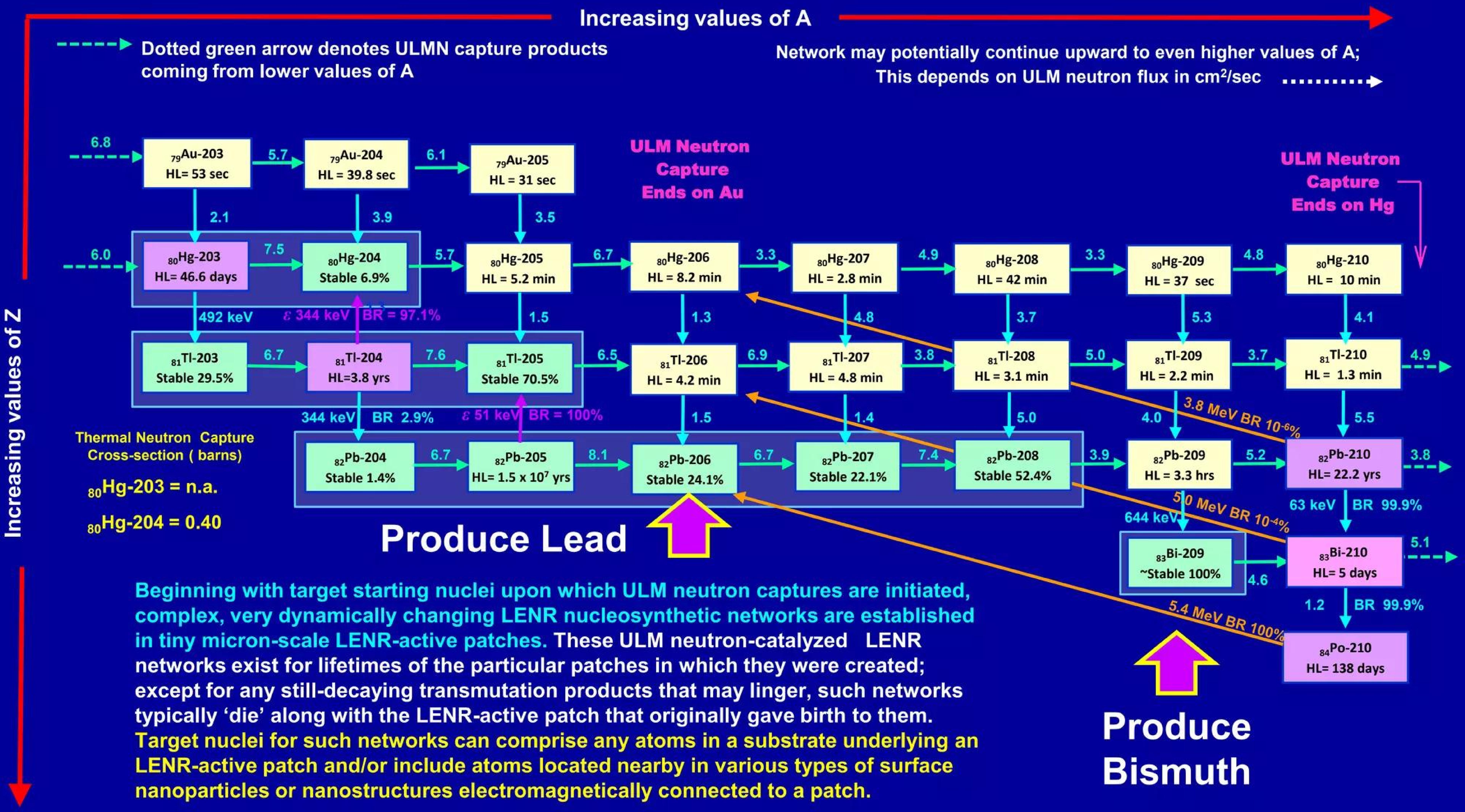
Neutron-catalyzed LENR networks

Example: network makes Platinum, Gold, Mercury, Lead, and Bismuth



Increasing values of A

Increasing values of Z

Dotted green arrow denotes ULMN capture products coming from lower values of A

Network may potentially continue upward to even higher values of A; This depends on ULM neutron flux in cm^2/sec

ULM Neutron Capture Ends on Au

ULM Neutron Capture Ends on Hg

6.8 → $_{79}$Au-203 HL= 53 sec → 5.7 → $_{79}$Au-204 HL = 39.8 sec → 6.1 → $_{79}$Au-205 HL = 31 sec

2.1 — 3.9 — 3.5

6.0 → $_{80}$Hg-203 HL= 46.6 days → 7.5 → $_{80}$Hg-204 Stable 6.9% → 5.7 → $_{80}$Hg-205 HL = 5.2 min → 6.7 → $_{80}$Hg-206 HL = 8.2 min → 3.3 → $_{80}$Hg-207 HL = 2.8 min → 4.9 → $_{80}$Hg-208 HL = 42 min → 3.3 → $_{80}$Hg-209 HL = 37 sec → 4.8 → $_{80}$Hg-210 HL = 10 min

492 keV — ε 344 keV BR = 97.1% — 1.5 — 1.3 — 4.8 — 3.7 — 5.3 — 4.1

$_{81}$Tl-203 Stable 29.5% → 6.7 → $_{81}$Tl-204 HL=3.8 yrs → 7.6 → $_{81}$Tl-205 Stable 70.5% → 6.5 → $_{81}$Tl-206 HL = 4.2 min → 6.9 → $_{81}$Tl-207 HL = 4.8 min → 3.8 → $_{81}$Tl-208 HL = 3.1 min → 5.0 → $_{81}$Tl-209 HL = 2.2 min → 3.7 → $_{81}$Tl-210 HL = 1.3 min → 4.9

344 keV BR 2.9% — ε 51 keV BR = 100% — 1.5 — 1.4 — 5.0 — 4.0 — 5.5

3.8 MeV BR 10^{-6}%

$_{82}$Pb-204 Stable 1.4% → 6.7 → $_{82}$Pb-205 HL= 1.5 x 10^7 yrs → 8.1 → $_{82}$Pb-206 Stable 24.1% → 6.7 → $_{82}$Pb-207 Stable 22.1% → 7.4 → $_{82}$Pb-208 Stable 52.4% → 3.9 → $_{82}$Pb-209 HL = 3.3 hrs → 5.2 → $_{82}$Pb-210 HL= 22.2 yrs → 3.8

5.0 MeV BR 10^{-4}%

644 keV — 63 keV BR 99.9%

$_{83}$Bi-209 ~Stable 100% → 4.6 — $_{83}$Bi-210 HL= 5 days → 5.1

1.2 BR 99.9%

5.4 MeV BR 100%

$_{84}$Po-210 HL= 138 days

Thermal Neutron Capture Cross-section (barns)

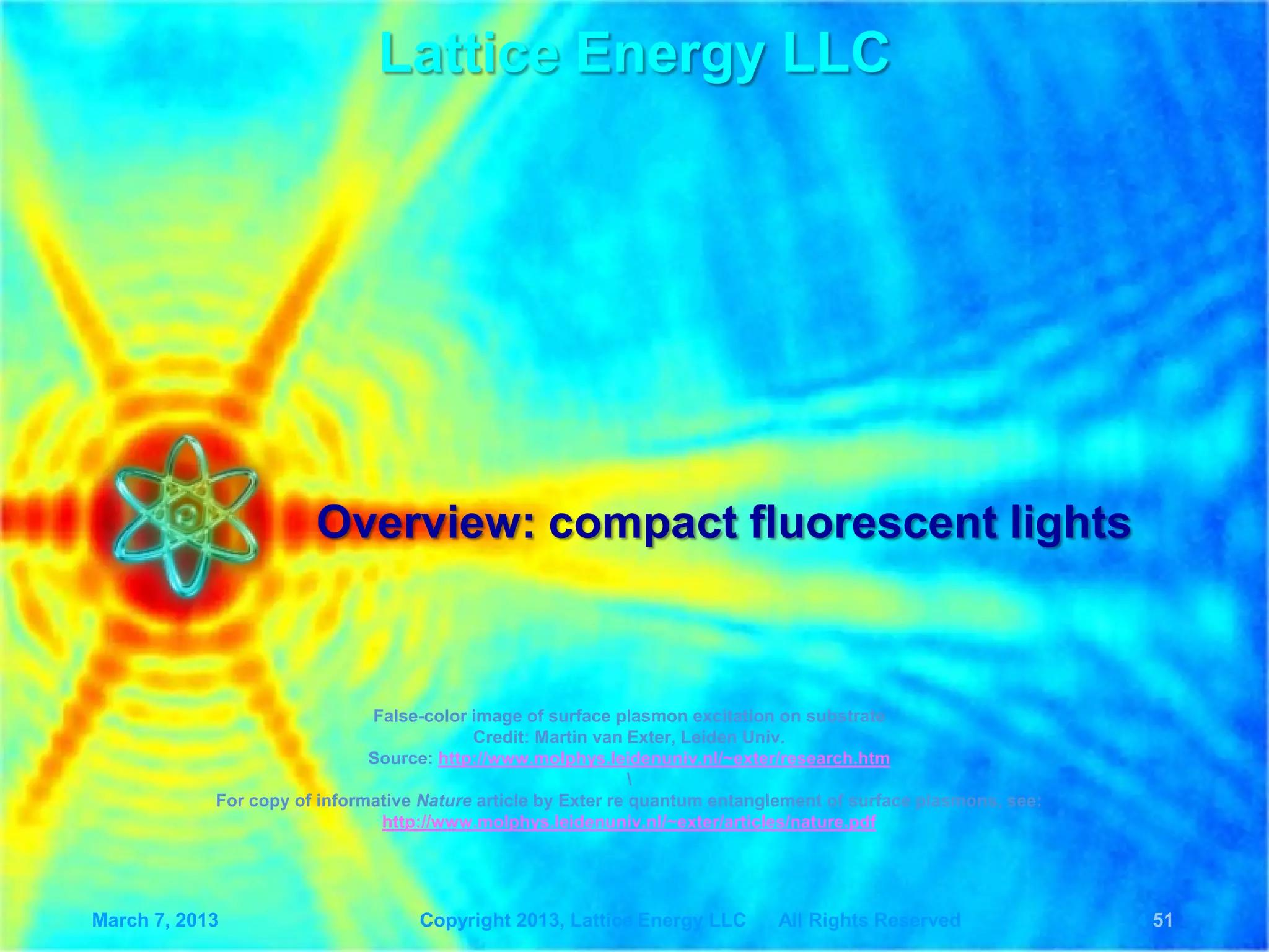
$_{80}$Hg-203 = n.a.

$_{80}$Hg-204 = 0.40

Produce Lead

Produce Bismuth

Beginning with target starting nuclei upon which ULM neutron captures are initiated, complex, very dynamically changing LENR nucleosynthetic networks are established in tiny micron-scale LENR-active patches. These ULM neutron-catalyzed LENR networks exist for lifetimes of the particular patches in which they were created; except for any still-decaying transmutation products that may linger, such networks typically 'die' along with the LENR-active patch that originally gave birth to them. Target nuclei for such networks can comprise any atoms in a substrate underlying an LENR-active patch and/or include atoms located nearby in various types of surface nanoparticles or nanostructures electromagnetically connected to a patch.



Overview: compact fluorescent lights

False-color image of surface plasmon excitation on substrate
Credit: Martin van Exter, Leiden Univ.
Source: http://www.molphys.leidenuniv.nl/~exter/research.htm
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For copy of informative *Nature* article by Exter re quantum entanglement of surface plasmons, see:
http://www.molphys.leidenuniv.nl/~exter/articles/nature.pdf

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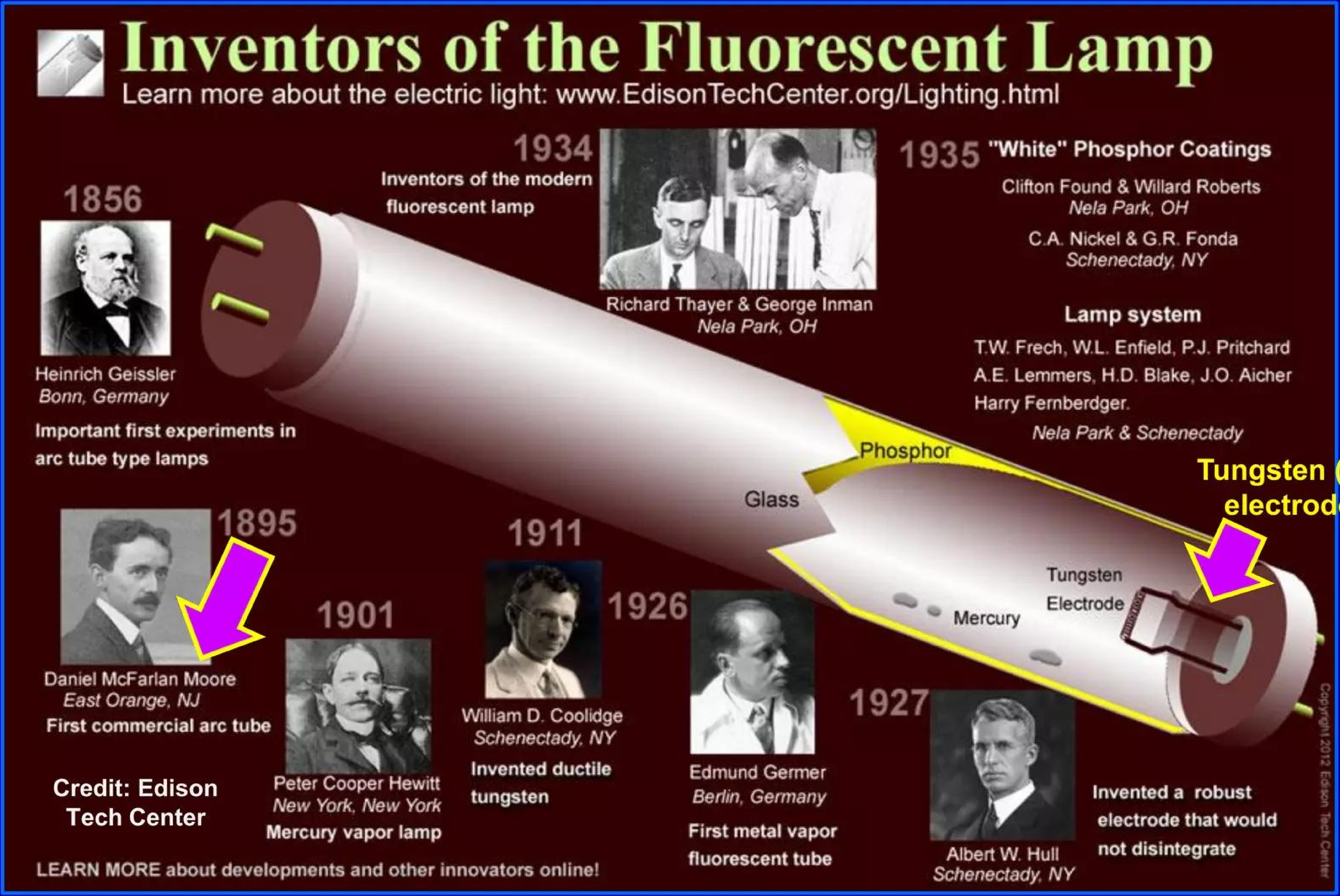
Overview: compact fluorescent lights

Commercial arc tube lighting technology goes way back to 1895



Inventors of the Fluorescent Lamp

Learn more about the electric light: www.EdisonTechCenter.org/Lighting.html

1856

Heinrich Geissler
Bonn, Germany

Important first experiments in arc tube type lamps

1895

Daniel McFarlan Moore
East Orange, NJ

First commercial arc tube

1901

Peter Cooper Hewitt
New York, New York

Mercury vapor lamp

1911

William D. Coolidge
Schenectady, NY

Invented ductile tungsten

1926

Edmund Germer
Berlin, Germany

First metal vapor fluorescent tube

1927

Albert W. Hull
Schenectady, NY

Invented a robust electrode that would not disintegrate

1934

Inventors of the modern fluorescent lamp

Richard Thayer & George Inman
Nela Park, OH

1935 "White" Phosphor Coatings

Clifton Found & Willard Roberts
Nela Park, OH

C.A. Nickel & G.R. Fonda
Schenectady, NY

Lamp system

T.W. Frech, W.L. Enfield, P.J. Pritchard
A.E. Lemmers, H.D. Blake, J.O. Aicher
Harry Fernberdger.
Nela Park & Schenectady

Tungsten (W) electrode

Credit: Edison Tech Center

LEARN MORE about developments and other innovators online!

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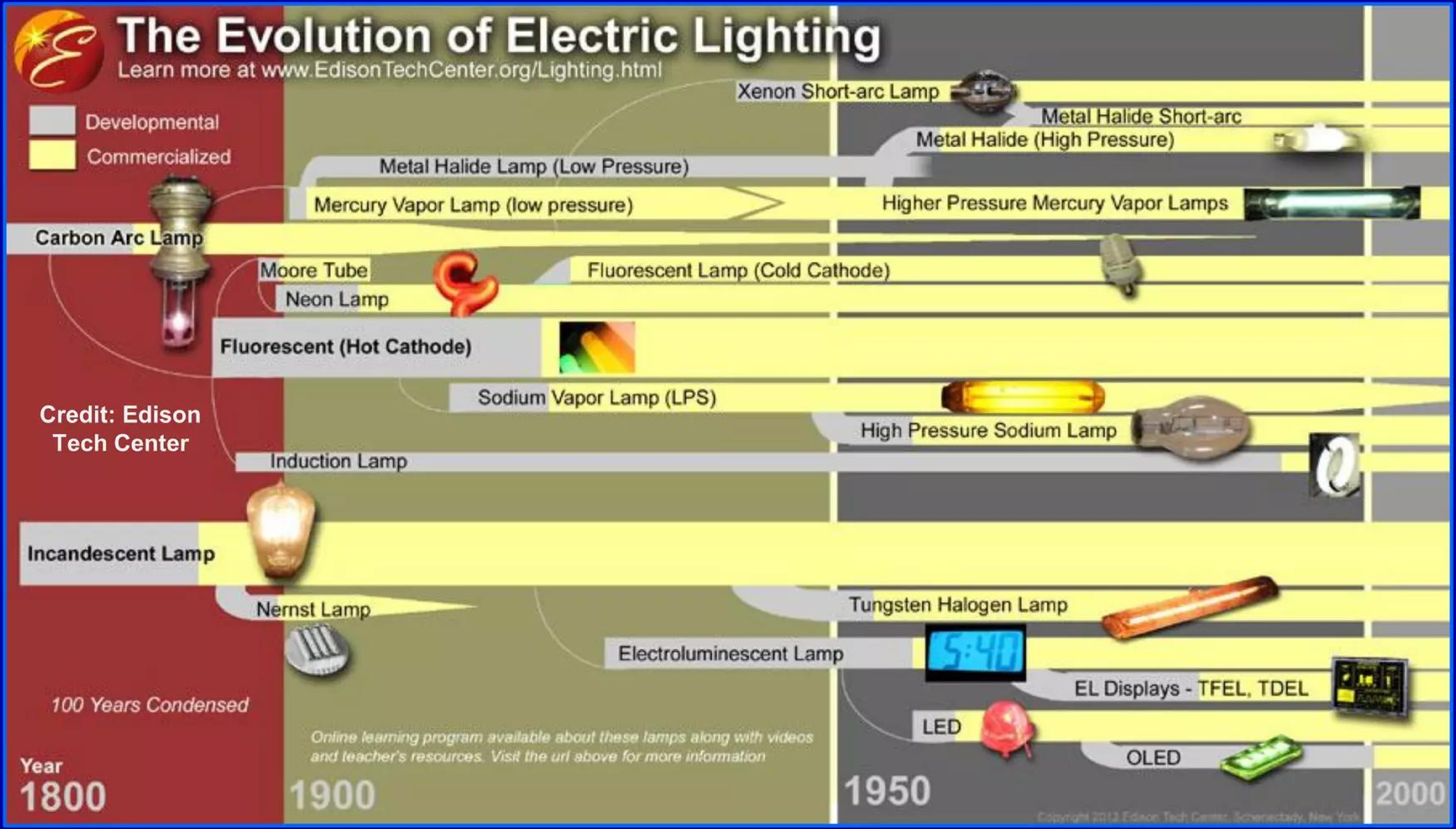
Overview: compact fluorescent lights

Historical timeline of various electric lighting technologies since 1800



Credit: Edison Tech Center

Overview: compact fluorescent lights

Fluorescent lights come in straight tubes, curves, and spirals

Source: http://en.wikipedia.org/wiki/Fluorescent_lamp [as of March 5, 2013]

Fluorescent lamp tube:

"Is filled with a gas containing low pressure mercury vapor and argon, xenon, neon, or krypton. The pressure inside the lamp is around 0.3% of atmospheric pressure. The inner surface of the lamp is coated with a fluorescent (and often slightly phosphorescent) coating made of varying blends of metallic and rare-earth phosphor salts. The lamp's electrodes are typically made of coiled tungsten and usually referred to as cathodes because of their prime function of emitting electrons. For this, they are coated with a mixture of barium, strontium and calcium oxides chosen to have a low thermionic emission temperature."

"Fluorescent lamp tubes are typically straight and range in length from about 100 millimeters (3.9 in) for miniature lamps, to 2.43 meters (8.0 ft) for high-output lamps. Some lamps have the tube bent into a circle, used for table lamps or other places where a more compact light source is desired. Larger U-shaped lamps are used to provide the same amount of light in a more compact area, and are used for special architectural purposes."

"Light-emitting phosphors are applied as a paint-like coating to the inside of the tube. The organic solvents are allowed to evaporate, and then the tube is heated to nearly the melting point of glass to drive off remaining organic compounds and fuse the coating to the lamp tube. Careful control of the grain size of the suspended phosphors is necessary; large grains, 35 micrometers or larger, lead to weak grainy coatings, whereas too many small particles 1 or 2 micrometers or smaller leads to poor light maintenance and efficiency. Most phosphors perform best with a particle size around 10 micrometers. The coating must be thick enough to capture all the ultraviolet light produced by the mercury arc, but not so thick that the phosphor coating absorbs too much visible light. The first phosphors were synthetic versions of naturally occurring fluorescent minerals, with small amounts of metals added as activators. Later other compounds were discovered, allowing differing colors of lamps to be made."

Compact fluorescent lights (CFLs):

"Have several small-diameter tubes joined in a bundle of two, four, or six, or a small diameter tube coiled into a spiral, to provide a high amount of light output in little volume."

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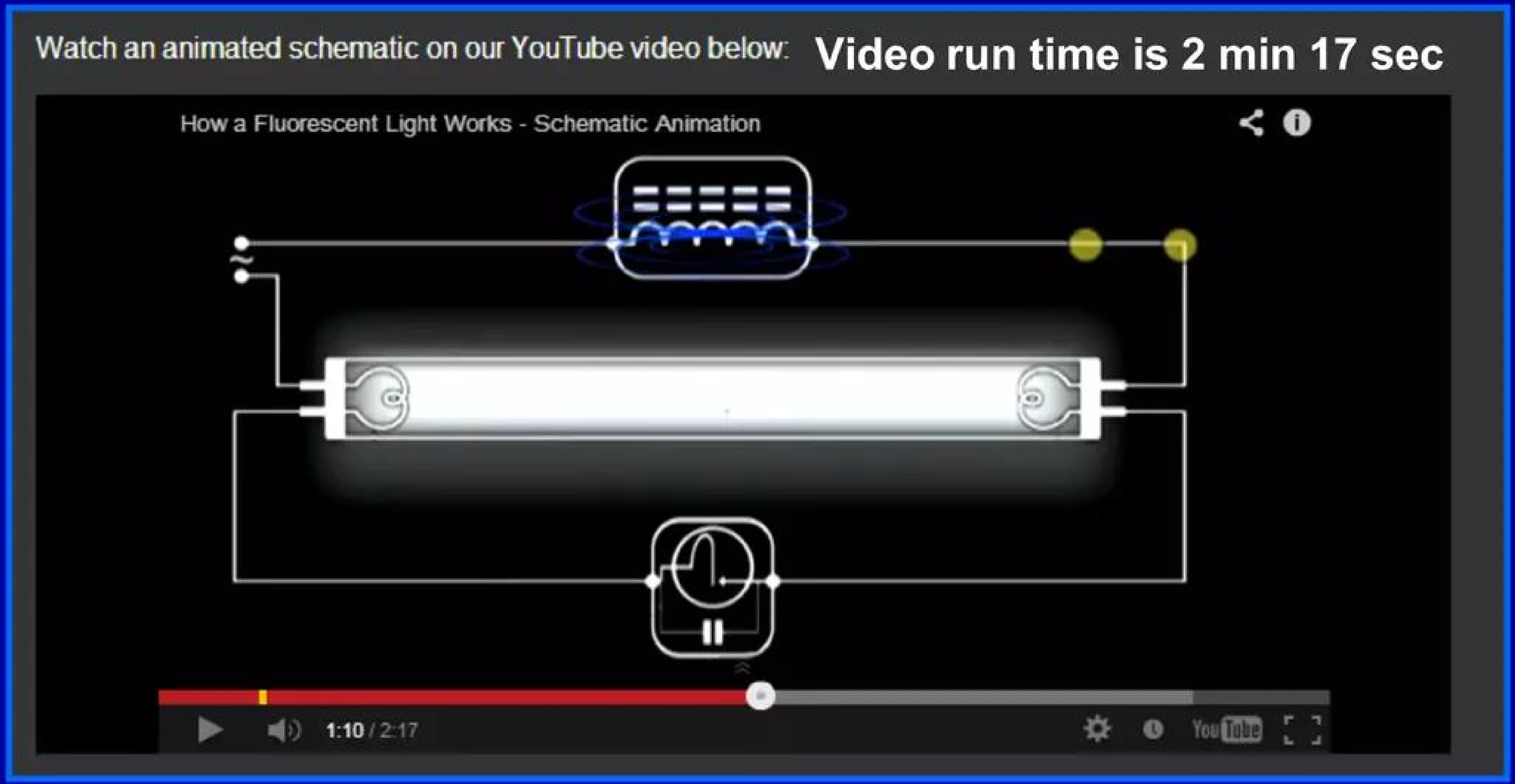
Overview: compact fluorescent lights

Details of common straight fluorescent tubes used for many decades

Image credit: Edison Tech Center


Watch an animated schematic on our YouTube video below:

Video run time is 2 min 17 sec

See very informative Edison Tech Center YouTube video at http://www.youtube.com/watch?feature=player_embedded&v=z55566ep0Hg

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Overview: compact fluorescent lights

Illustrates key details of fluorescent tube start-up process sequence

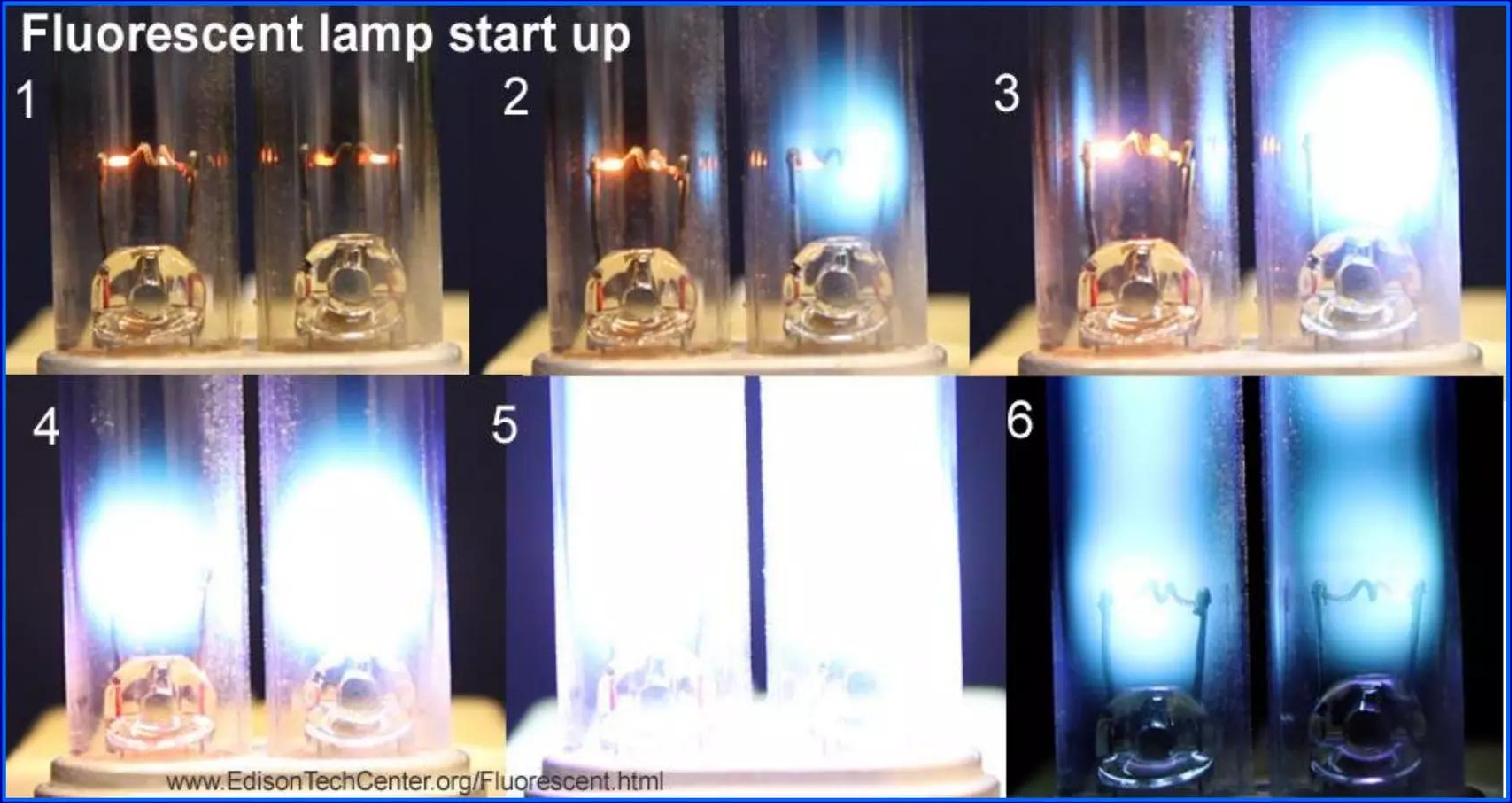

Image credit: Edison Tech Center at http://www.edisontechcenter.org/Fluorescent.html

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Overview: compact fluorescent lights

Details of metallic electrodes found in a typical fluorescent tube

Note: both electrodes composed of Tungsten (W) ; hot lamp has ionized Argon gas and vaporized Mercury

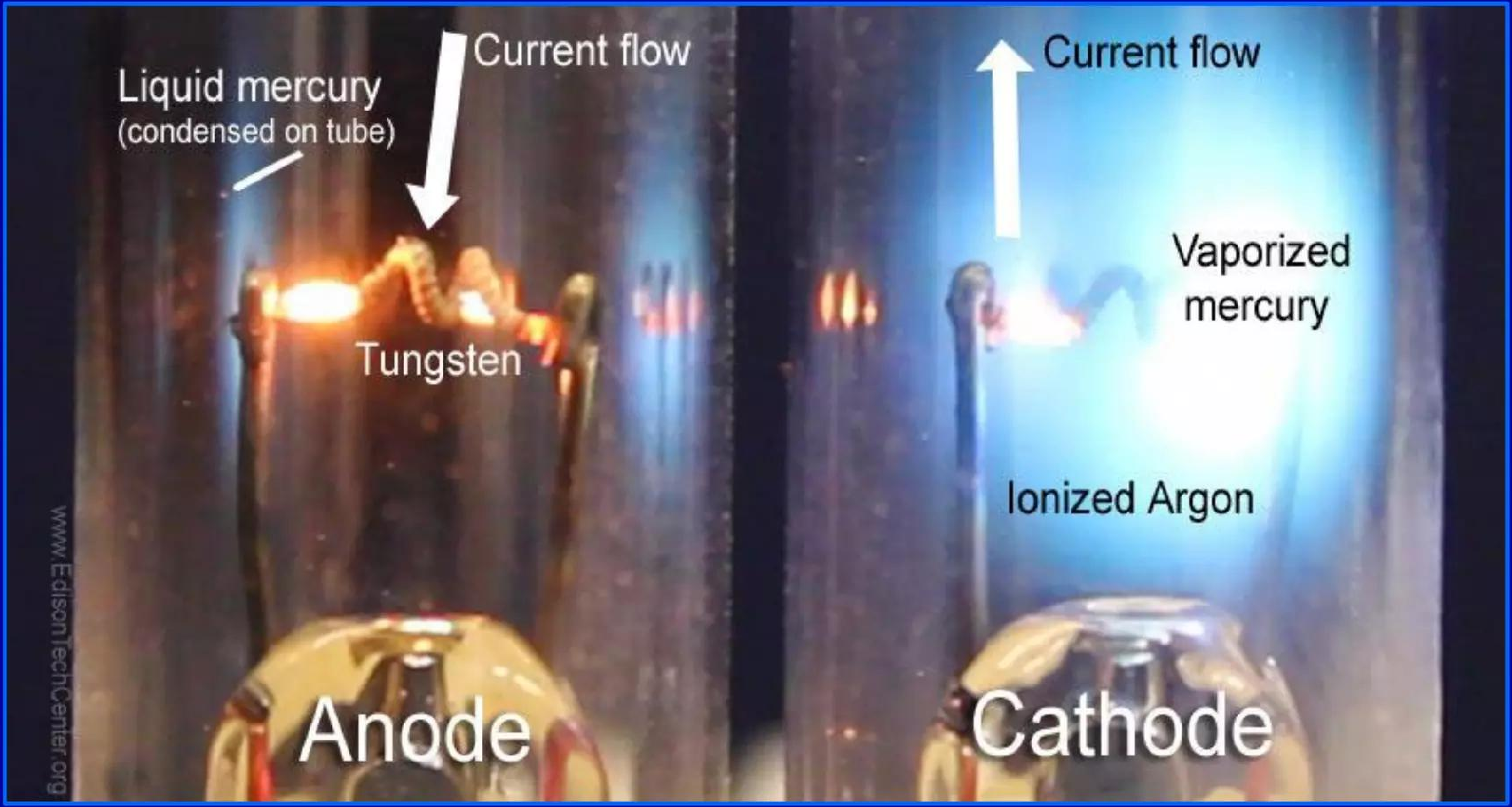

Image credit: Edison Tech Center at http://www.edisontechcenter.org/Fluorescent.html

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Overview: compact fluorescent lights

Historical timeline of various electric lighting technologies since 1800

When excited, ionized Mercury emits UV photons; phosphors absorb UV and re-radiate visible photons in various colors

Image credits: Edison Tech Center at http://www.edisontechcenter.org/Fluorescent.html

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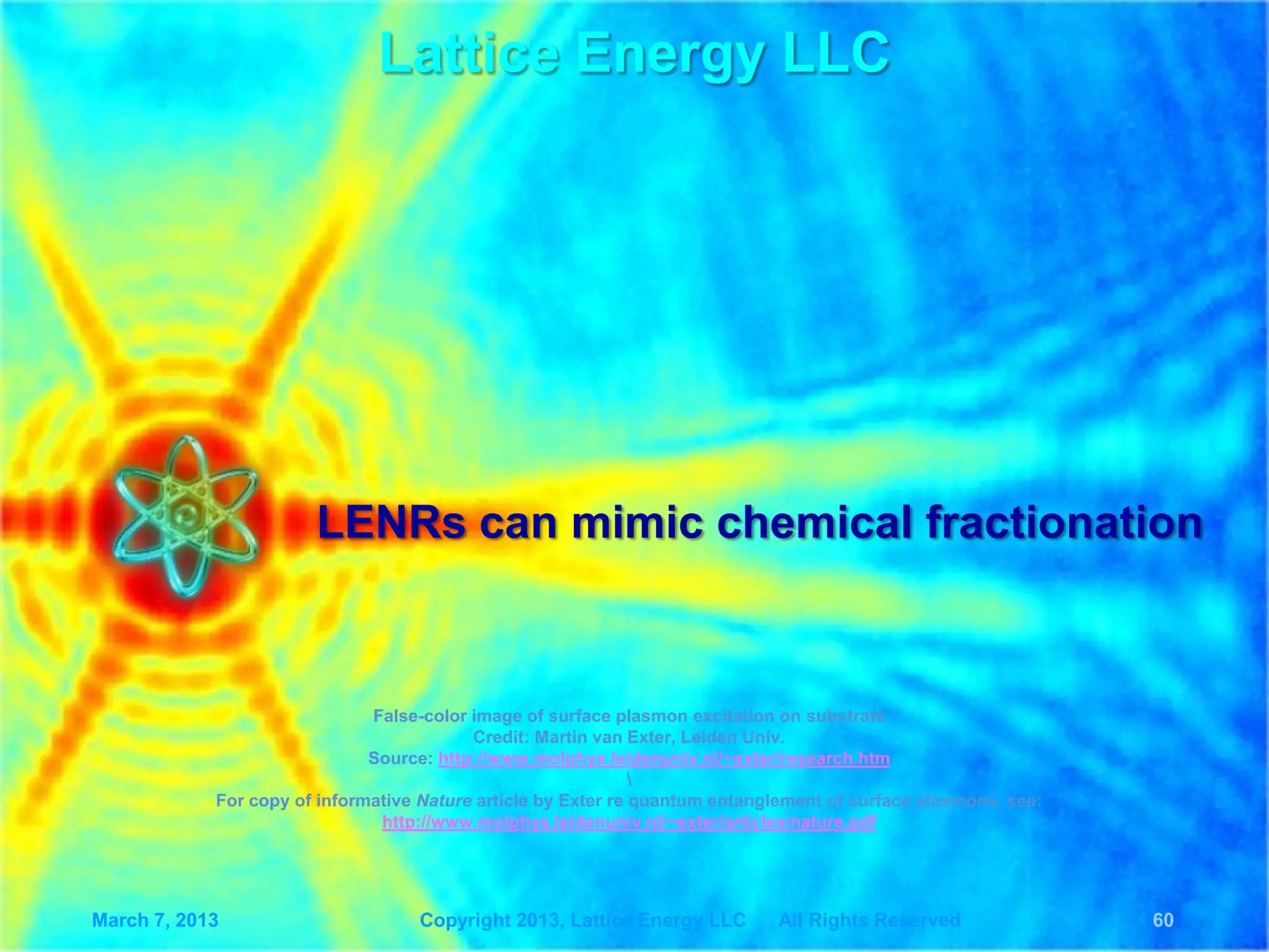
Overview: compact fluorescent lights

Today's compact fluorescent lights are a relatively recent development



LENRs can mimic chemical fractionation

False-color image of surface plasmon excitation on substrate
Credit: Martin van Exter, Leiden Univ.
Source: http://www.molphys.leidenuniv.nl/~exter/research.htm
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For copy of informative *Nature* article by Exter re quantum entanglement of surface plasmons, see:
http://www.molphys.leidenuniv.nl/~exter/articles/nature.pdf

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LENRs can mimic chemical fractionation

W-L posit chemical and nuclear processes coexist in many systems

LENRs versus chemical fractionation explanations for anomalous isotopic shifts

Before proceeding further, let it be crystal clear to readers exactly what we are and are not saying here:

- ✓ **We are not asserting that the existing chemical fractionation paradigm fails to adequately explain most reported isotope anomalies with respect to statistically significant deviations from natural abundances --- indeed, it may well effectively and accurately explain the vast majority of them**
- ✓ **We are saying that presently published literature does contain a significant subset comprising many cases such as Mead *et al*. (2013) in which a chemical fractionation paradigm must be pushed very, very hard (which includes use of various *ad hoc* constructs) to explain certain otherwise inexplicable isotope anomalies; paradigm is being overly stretched to be able to comfortably accommodate anomalous data**
- ✓ **We are suggesting that when confronted with otherwise totally inexplicable isotopic or elemental data, it may be fruitful for researchers to reexamine such data through the conceptual lens of the LENR paradigm to see if invoking nuclear transmutation leads to a deeper, better understanding of otherwise perplexing results. In some instances, LENRs may illuminate; in others not --- but we should examine anyway**

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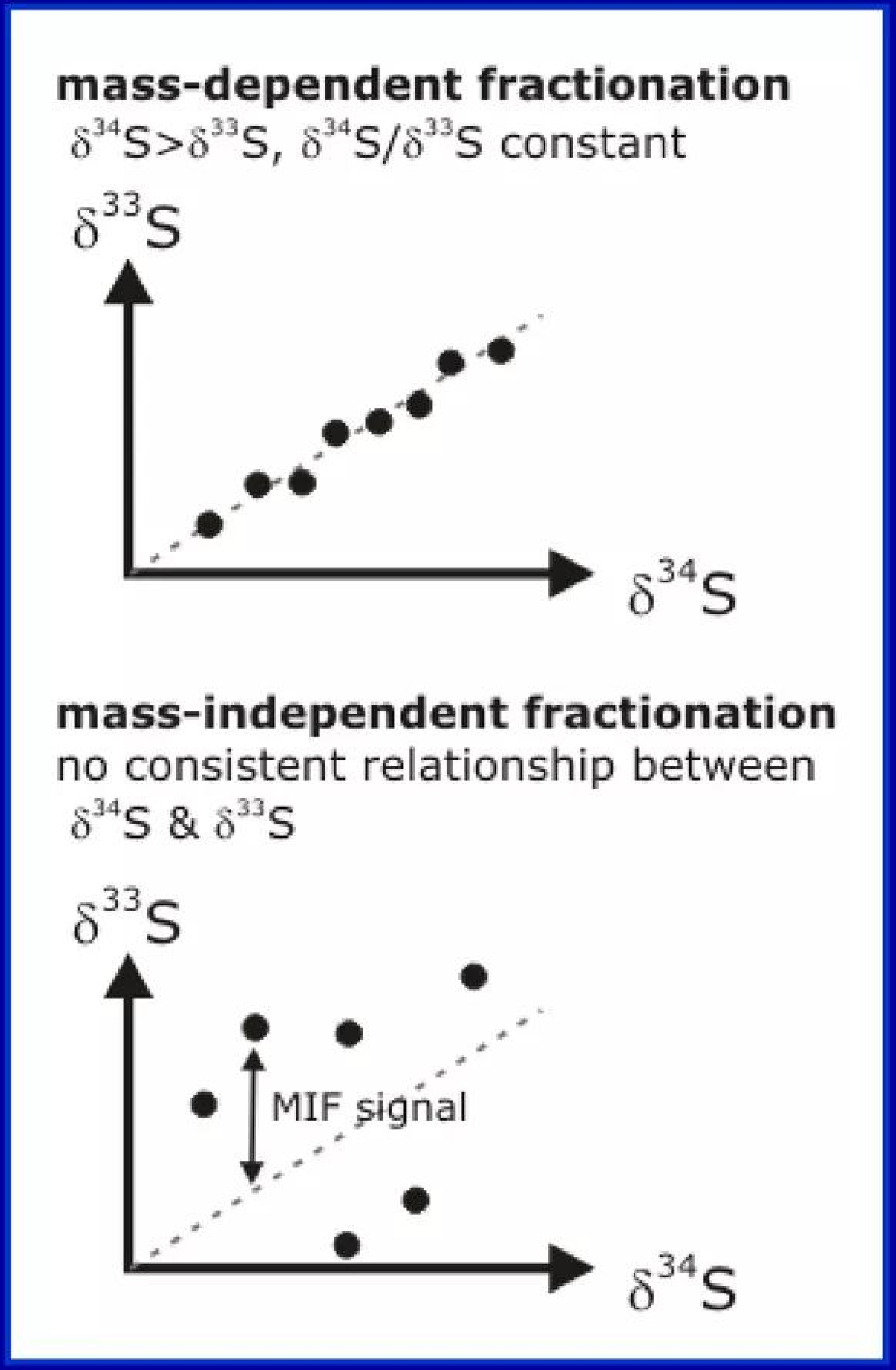
W-L posit chemical and nuclear processes coexist in many systems

Chemical fractionation paradigm assumes that no nuclear processes are present

- ✓ For ~ 60 years, a body of theory has been developed and articulated to explain progressively increasing numbers of stable isotope anomalies observed in a vast array of mass spectroscopic data obtained from many different types of natural and experimental, abiological and biological, systems. Central ideas in chemical "fractionation" theory embody equilibrium and irreversible, mass-dependent and mass-independent, chemical processes that are claimed to separate isotopes, thus explaining the reported anomalies
- ✓ Although not explicitly acknowledged by fractionation theorists, an intrinsic fundamental assumption underlying all of this theory and interpretation of data is that no nucleosynthetic processes are occurring anywhere in any of these systems, at any time, that are capable of altering isotope ratios and/or producing new mixtures of different elements over time; ergo, chemistry explains everything
- ✓ However, if Widom-Larsen theory is correct, for some of this data the above fundamental assumption may be wrong



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Modern isotopic analysis using mass spectroscopy began back in the 1920s

- ✓ Modern isotopic chemical analysis using mass spectrometry initially began in the early 1920s as scientists started designing and building progressively better, more sensitive types of instruments; the scientific community gradually began to systematically measure and publish abundances of stable and unstable isotopes found on earth as well as in meteoritic materials that reached the earth's surface from outer space, i.e., most likely from elsewhere in the solar system
- ✓ Extensive compilations of varied isotopic data eventually lead to the idea of the "*natural abundances*": natural abundance (NA) refers to the isotopic composition of a given chemical element as it is naturally found on a particular planet, e.g., earth. For a given element composed of one or more isotopes, a weighted average of the naturally occurring composition of these isotopes (natural abundance) is the specific value for atomic weight that is listed for that element in the periodic table. Note that although the 'natural' isotopic composition of a given chemical element can vary from planet to planet, in theory it should remain essentially constant over geological time (except in the case of elements having one or more radioactive isotopes)
- ✓ On a given planet, the characteristic isotopic composition of a given element, i.e., its natural abundance, should be essentially identical everywhere. For example, in the case of the element Copper on earth, it is comprised of two stable isotopes that typically occur in ~ following proportions: 69% Cu-63 and 31% Cu-65. With many terrestrial elements, one out of several stable isotopes frequently predominates; others may be present only in minor traces, e.g., in the case of natural Oxygen one would in principle measure ~ 99.759% O-16; 0.0374% O-17; and 0.2039% O-18

LENRs can mimic chemical fractionation

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By 1947 chemical fractionation theorists assumed absence of nuclear processes

- ✓ **Statistically significant deviations from natural abundances began to appear in some early isotopic data collected by scientists; such anomalies were observed in many different types of experimental chemical reaction systems and in the natural environment, as well as in meteoritic materials**
- ✓ **Given that the observed isotopic anomalies in question obviously did not involve material freshly processed in stars, fission reactors, or nuclear explosions, it was readily assumed that significant deviations from natural isotopic abundances had to be the result of chemical processes**
- ✓ **In the 1940-50s, early theories of "chemical fractionation" were published in an effort to explain significant anomalies from natural abundances found in some experimental data. These early theories mainly involved equilibrium isotope effects in reversible chemical systems and kinetic effects of isotopes on reaction rates in irreversible chemical systems (details will explained shortly in subsequent slides)**

One example of a classic paper on abundances is: White, J. R. and Cameron, A. E., "The Natural Abundance of Isotopes of Stable Elements," *Physical Review* 74 pp. 991-1000 (1948)

Two widely cited early papers on chemical isotopic fractionation are as follows:

Bigeleisen, J. and Mayer, M. J., "Calculation of equilibrium constant for isotope exchange reaction," *Chem. Phys*. 15 pp. 261-267 (1947)

Urey, H.C., "The thermodynamic properties of isotopic substances," *J. Chem. Soc.* pp. 562-581 (1947)

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Mass-independent fractionation 'explains' isotope shifts seen in heavier elements

- ✓ Since the 1950s, development of an increasing variety of progressively improved, much less expensive, and substantially more accurate mass spectroscopy techniques has enabled M-S to be utilized in many different fields. A vast quantity of reliable isotopic data has thus accumulated
- ✓ Since early theories of chemical isotopic fractionation were directly tied to mass differences between isotopes, their applicability was generally limited to lighter elements in the Periodic Table (from Hydrogen out through roughly Sulfur) where % differences in relative masses are large enough to have a plausibly significant impact on isotopic separation via some form of mass-sensitive physico-kinetic process
- ✓ Today's fractionation theories include equilibrium and kinetic effects and mass-independent: nuclear field shift, photochemical, and Q-M symmetry effects that attempt to extend such concepts to accommodate much higher-mass elements-isotopes in the Periodic Table --- even Uranium

The first reliable report of an of an isotopic anomaly that could not plausibly be explained by simple physical processes such as condensation or evaporation --- phase changes --- (i.e., it was mass-independent) was published by Clayton, R., Grossman, L., and Mayeda, T., "A component of primitive nuclear composition in carbonaceous meteorites," *Science* 182 pp. 485 - 488 (1973)

Mass-independent fractionation now utilized to explain a growing body of anomalous, perhaps otherwise chemically inexplicable isotopic data. For Oxygen, see Michalski, G. and Bhattacharya, S., "Role of symmetry in the mass-independent isotope effect in ozone," *PNAS* 106 pp. S493-S496 (2009)

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Definition of key term: isotopic fractionation factor = *f*

Isotope fractionation: "… is the physical phenomenon which causes changes in the relative abundance of isotopes due to their differences in mass. There are two categories of isotope effects: equilibrium and kinetic."

"An equilibrium isotope effect will cause one isotope to concentrate in one component of a reversible system that is in equilibrium. If it is the heavier isotope that concentrates in the component of interest, then that component is commonly referred to as enriched or heavy. If it is the light isotope that concentrates then the component is referred to as depleted or light. In most circumstances the heavy isotope concentrates in the component in which the element is bound more strongly and thus equilibrium isotope effects usually reflect relative differences in the bond strengths of the isotopes in the various components of the system. A kinetic isotope effect occurs when one isotope reacts more rapidly than the other in an irreversible system or a system in which the products are swept away from the reactants before they have an opportunity to come to equilibrium. Normally, the lighter isotope will react more rapidly than the heavy isotope and thus the product will be lighter than the reactant."

"It should be noted that isotope fractionation will only occur in systems in which there is both an isotope effect and a reaction that does not proceed to completion. Thus, even in the presence of an isotope effect, there will be no isotope fractionation if all the reactant goes to a single product because all the atoms have reacted and thus the ratio of the heavy to light isotope must be the same in the product as it was in the reactant. The magnitude of an isotope effect is expressed as a fractionation factor. This *f* is defined as the ratio of the heavy to light isotope in the product divided by the ratio of the heavy to light isotope in the reactant. Stated mathematically:"

$$f = \frac{(heavy\,/\,light)\text{product}}{(heavy\,/\,light)\text{reactant}}$$

"When f is greater than 1, the product is heavy or enriched. When it is less than 1, the product is light or depleted. Most fractionation factors lie between 0.9 and 1.1, but deuterium isotope effects can result in much smaller or larger fractionation factors. A fractionation factor of 1.050 is often referred to as a 5% isotope effect."

Source of definitions: D. Schoeller and A. Coward at http://www.unu.unupress/food2/uid05e/uid05e0e.htm

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LENRs can mimic chemical fractionation

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Definition of key term: mass-independent fractionation

"Mass-independent (isotope) fractionation: refers to any chemical or physical process that acts to separate isotopes, where the amount of separation does not scale in proportion with the difference in the masses of the isotopes. Most isotope fractionations (including typical kinetic fractionations and equilibrium fractionations) are caused by the effects of the mass of an isotope on atomic or molecular velocities, diffusivities, or bond strengths. **Mass-independent fractionation processes are less common, occurring mainly in photochemical and spin-forbidden reactions**. Observation of mass-independently fractionated materials can therefore be used to trace these types of reactions in nature and in laboratory experiments."

"Mass-independent fractionation in nature: the most notable examples of mass-independent fractionation in nature are found in the isotopes of oxygen and sulfur. The first example was discovered by Robert N. Clayton, Toshiko Mayeda, and Lawrence Grossman in 1973, in the oxygen isotopic composition of refractory calcium-aluminum-rich inclusions in the Allende meteorite. The inclusions, thought to be among the oldest solid materials in the Solar System, show a pattern of low $^{18}O/^{16}O$ and $^{17}O/^{16}O$ relative to samples from the Earth and Moon. Both ratios vary by the same amount in the inclusions, although the mass difference between ^{18}O and ^{16}O is almost twice as large as the difference between ^{17}O and ^{16}O. Originally this was interpreted as evidence of incomplete mixing of ^{16}O-rich material (created and distributed by a large star in a supernova) into the Solar nebula. However, recent measurement of the oxygen-isotope composition of the Solar wind, using samples collected by the Genesis spacecraft, shows that the most ^{16}O-rich inclusions are close to the bulk composition of the solar system. This implies that Earth, the Moon, Mars and asteroids all formed from ^{18}O- and ^{17}O-enriched material. **Photochemical dissociation of carbon monoxide in the Solar nebula has been proposed to explain this isotope fractionation**. Another important mass-independent fractionation is found in ozone in the stratosphere. 1:1 variation of $^{18}O/^{16}O$ and $^{17}O/^{16}O$ in ozone was discovered in laboratory synthesis experiments by John Heidenreich and Mark Thiemens in 1983, and later found in stratospheric air samples measured by Konrad Mauersberger. Theoretical calculations by Rudolph Marcus and others suggest that ^{18}O- and ^{17}O enrichment in ozone is caused by the effects of ^{17}O and ^{18}O on molecular symmetry, and on the lifetimes of intermediate, excited states in the synthesis reaction."

"Mass-independent fractionation: has also recently been discovered in sulfur from ancient geological samples, particularly those formed more than 2,450 million years ago, by James Farquhar, Huiming Bao, and Mark Thiemens. Although the details of the fractionation process are not yet known, it appears most likely to be caused by photochemical reactions involving sulfur-bearing molecules in the early atmosphere. The creation and transfer of the mass-independent signature into minerals would be unlikely in an atmosphere containing abundant oxygen, indicating that the atmosphere was anoxic during the Archaean eon, before 2,450 million years ago."

Source: quoted from Wikipedia as of June 3, 2010, at http://en.wikipedia.org/wiki/Mass-independent_fractionation

LENRs can mimic chemical fractionation

W-L posit chemical and nuclear processes coexist in many systems

Definition of key term: nuclear field shift effect

Nuclear field shift effect in mass independent isotope fractionation: "The classic theory of stable isotope fractionation in chemical exchange reactions has been established by Bigeleisen, Mayer, and Urey in 1947. The theory was based on the difference of molecular vibrational energies of isotopomers that are proportional to the respective masses, and hence, results in mass-dependent isotope effect only. In 1996, this conventional mass-dependent theory has been expanded by Bigeleisen to include a mass-independent term named the nuclear field shift effect. The nuclear field shift is an isotope shift in orbital electrons, which results from the isotopic difference in nuclear size and shape. The new equation defined by Bigeleisen (at a constant temperature) can be simply expressed as, $\ln \alpha = \delta\langle r^2\rangle A + (\delta m/mm')B$, where α is the isotope separation factor, δ<r2> isotopic difference in mean-square nuclear charge radius, δm difference between isotopic masses m and m'. A and B are scaling factors of the nuclear field shift effect and the conventional mass effect, respectively. **Since this new theory was presented, the mass-independent isotope fractionation of various elements, e.g., Ti, Cr, Ni, Zn, Sr, Zr, Mo, Ru, Cd, Te, Ba, Nd, Sm, Gd, Yb, and U, found in chemical exchange systems has been successfully explained as the nuclear field shift effect. In our most recent studies, the nuclear field shift effect of Cr, Mo, Ru, Cd, and Te isotopes has been found in laboratory scale experiments.** The isotopes of these elements were fractionated by using a liquid-liquid extraction system (a ligand exchange system) at room temperature. The isotopic analysis was performed by the multiple-collector inductively coupled plasma mass spectrometry (MC-ICP-MS) with a typical precision of <100 ppm (at ENS Lyon or UC Davis). Isotope enrichment factors did not show mass-dependent trend, but possessed a similar variation of their nuclear charge radii. For Cr, we tested a different chemical exchange system (a redox system): at high temperature (723-1023 K), an eutectic melt was contacted with a liquid metal. In this system, the nuclear field shift effect of Cr was also found. **All these experimental results suggest that the nuclear field shift effect may occur in every chemical exchange reaction at various temperatures to various degrees … isotopic anomalies found in a natural system might be partly or largely affected by the nuclear field shift effect via chemical reactions occurred in the nature. In order to clarify the degree and significance of its contribution, we may need to pay more attention to the nuclear field shift effect created chemically."**

Source: "Nuclear field shift effect in chemical exchange reactions," Fujii, T; Moynier, F; Yin, Q.; and Albarède, F. Meeting abstract for presentation: American Geophysical Union, San Francisco, California: December 10-14, 2007 at https://www.geology.ucdavis.edu/faculty/pubs/agu07/yin07_3.html

LENRs can mimic chemical fractionation

W-L posit chemical and nuclear processes coexist in many systems

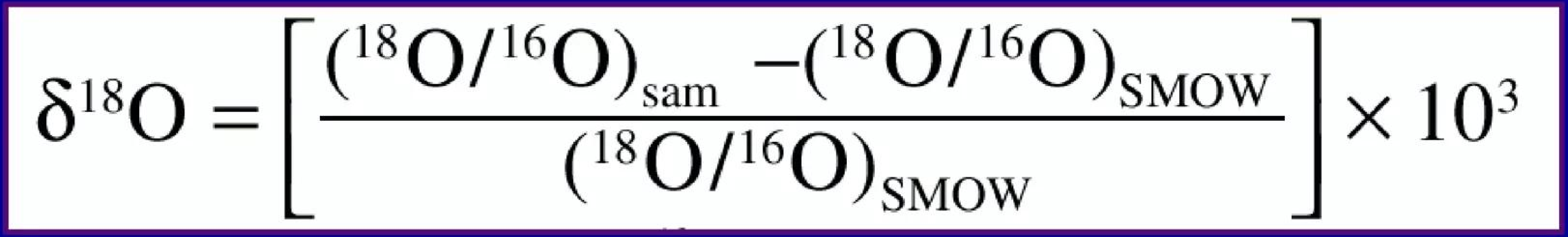
Definition of key term: δ-notation

Stable isotope ratios are commonly expressed in δ-notation:

$$\delta = \left(\frac{R_{\text{sample}} - R_{\text{standard}}}{R_{\text{standard}}} \right) \text{x } 1000$$

Wherein by convention: $R = \text{ratio} = \left(\frac{X_{\text{heavy isotope}}}{X_{\text{light isotope}}} \right)$

e.g.,



$$\delta^{18}O = \left[\frac{(^{18}O/^{16}O)_{\text{sam}} - (^{18}O/^{16}O)_{\text{SMOW}}}{(^{18}O/^{16}O)_{\text{SMOW}}} \right] \times 10^3$$

Source: Prof. Paul Asimow, Caltech, slide from a Geology lecture in 2006

LENRs can mimic chemical fractionation

W-L posit chemical and nuclear processes coexist in many systems

Established standards by convention for specific elements

The x1000 in previous slide implies that units on δ are parts per thousand, per mil, or ‰

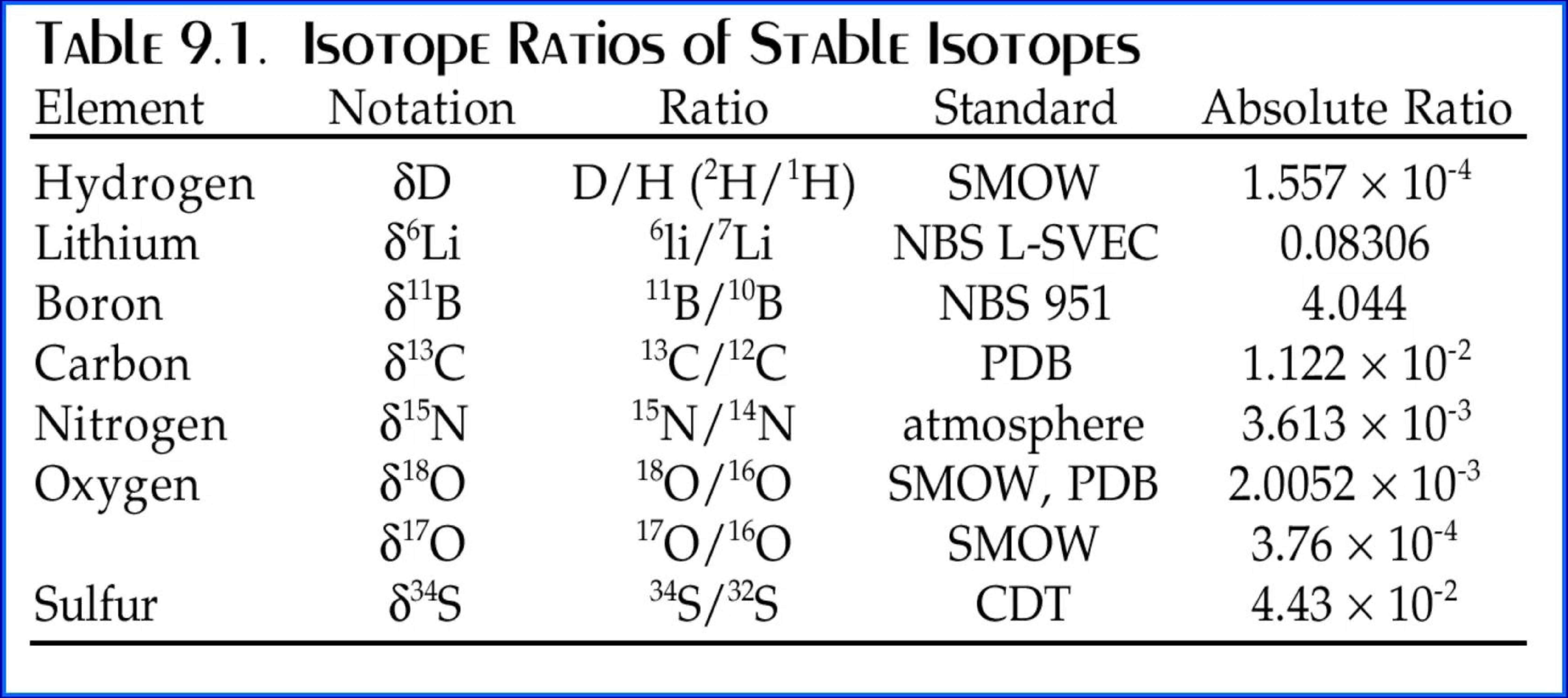


TABLE 9.1. ISOTOPE RATIOS OF STABLE ISOTOPES

Element	Notation	Ratio	Standard	Absolute Ratio
Hydrogen	δD	D/H (^{2}H/^{1}H)	SMOW	1.557×10^{-4}
Lithium	δ^{6}Li	^{6}li/^{7}Li	NBS L-SVEC	0.08306
Boron	δ^{11}B	^{11}B/^{10}B	NBS 951	4.044
Carbon	δ^{13}C	^{13}C/^{12}C	PDB	1.122×10^{-2}
Nitrogen	δ^{15}N	^{15}N/^{14}N	atmosphere	3.613×10^{-3}
Oxygen	δ^{18}O	^{18}O/^{16}O	SMOW, PDB	2.0052×10^{-3}
	δ^{17}O	^{17}O/^{16}O	SMOW	3.76×10^{-4}
Sulfur	δ^{34}S	^{34}S/^{32}S	CDT	4.43×10^{-2}

Source: Prof. Paul Asimow, Caltech, slide from a Geology lecture in 2006

LENRs can mimic chemical fractionation

W-L posit chemical and nuclear processes coexist in many systems

Example: natural variation in ratios of Carbon isotopes

Explanation of ${}_{13}C$ abundance variations according to a strictly chemical fractionation paradigm:

> **"The ratio of Carbon-12 to Carbon-13 is constant in earth's atmosphere. There are always 100 ${}_{12}C$ atoms to one ${}_{13}C$ atom. During the process of photosynthesis, plants absorb the carbon atoms in earth's atmosphere, water, and soil, and store them in the cells of their leaves, fruits, nuts, and roots. But as a result of the photosynthesis process, the ratio of the forms of carbon gets changed as it is being stored."**
>
> **"The alteration of the chemical ratio is different for plants in different parts of the world. For example, plants that live in regions with lots of sun and little water have relatively fewer ${}_{12}C$ atoms in their cells (compared to${}_{13}C$) than do plants that live in forests or wetlands. This ratio is hardwired into the plant's cells, and - here's the best part - as the cells get passed up the food chain (i.e., the roots, leaves, and fruit are eaten by animals and humans), the ratio of ${}_{12}C$ to ${}_{13}C$) remains virtually unchanged as it is in turned stored in bones, teeth and hair of the animals and humans."**
>
> **"In other words, if you can determine the ratio of ${}_{12}C$ to ${}_{13}C$ in an animal's bones, you can figure out what kind of climate the plants it ate during its lifetime came from. The measuring takes mass spectrometer analysis; but that's another story, too."**

Source: http://archaeology.about.com/od/stableisotopes/qt/dummies.htm

LENRs can mimic chemical fractionation

W-L posit chemical and nuclear processes coexist in many systems

Key chemical fractionation theory assumptions violated on small length-scales

- ✓ As background, let us briefly review some underlying, implicit assumptions about chemical systems that have not been much questioned since 1912, when Bohr and Rutherford formulated modern ideas of atomic structure and 1927, when the Born-Oppenheimer approximation (which is a physically justifiable simplifying assumption) made quantum mechanical calculations mathematically tractable for less complicated atoms such as hydrogen and not-too-large molecules (e.g., benzene)
- ✓ After 1927, chemistry's recognized domain was narrowed to comprise phenomena involving electron clouds surrounding atomic nuclei and the dynamics of outer valence electrons that interact with Coulomb electric fields induced by positively charged protons in nuclei; particle energies in chemical systems are thus typically in the eV range. Chemistry typically involves atomic and molecular phenomena at temperatures of up to ~6,000^o C and non-degenerate electron pressures; it customarily excludes subatomic particles and their very fast, vastly more energetic MeV-and-higher nuclear reactions, as well as matter found in extremely hot, highly ionized plasmas at temperatures of up to millions of degrees

"Toto, I have the feeling we're not in Kansas anymore," Dorothy in "The Wizard of Oz" (1939)

"There is nothing as deceptive as an obvious fact," Sherlock Holmes, "The Boscombe Valley Mystery" (1891)

"These are very deep waters," Sherlock Holmes, "The Adventure of the Speckled Band" (1892)

" … when you have eliminated the impossible, whatever remains, however improbable, must be the truth," Sherlock Holmes, "The Sign of the Four" (1890)

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LENRs can mimic chemical fractionation

W-L posit chemical and nuclear processes coexist in many systems

Key chemical fractionation theory assumptions violated on small length-scales

According to W-L theory: in condensed matter chemical systems (as opposed to large-length-scale, magnetically dominated regimes explained in our technical publications), LENRs are primarily surface phenomena that can, under exactly the right conditions, occur in scattered, discrete regions with dimensions that range from as little as ~0.28 nanometers (benzene ring) up to ~100 microns (10^5 nm) on metal hydrides. In such tiny, uniquely different surface regions:

- ✓ **Born-Oppenheimer approximation breaks down; many-body electron-nucleon (p+, d+, t+) dynamics can locally become electromagnetically (E-M) coupled (think of these hydrogen atoms behaving as 'bare nuclei')**
- ✓ **Many-body, collectively oscillating, coherent (i.e., particles effectively Q-M entangled), spatially contiguous collections of protons, deuterons, or tritons E-M couple to immediately adjacent surface plasmon electrons on metallic hydride surfaces; or, collectively oscillating π electrons located on the surfaces of benzene rings, polycyclic aromatic hydrocarbons (PAHs), fullerenes, and graphane/graphene structures**
- ✓ **Local coupling of many-body, collective oscillations of protons/deuterons/tritons with electrons creates nuclear-strength local electric fields $>10^{11}$ V/m that renormalize masses of coupled electrons (e^*); this enables ultra low momentum neutron (ULMN) production via $e^* + p^+$ or $e^* + d^+$ weak interaction; ULMNs captured locally**
- ✓ **Purely chemical reactions always conserve and preserve elements found in both reactants and products; once ULM neutrons are introduced to a system, conservation of elements assumption is not necessarily valid**

In systems with LENRs, some of chemistry's key fundamental assumptions break down and are violated on small length scales. Thus, while pure chemistry may reign supreme on 98 - 99% of a given sample surface, there can be many tiny sub-regions comprising just a few % of the total surface area in which W-L weak interaction-dominated nuclear processes can also occur

LENRs can mimic chemical fractionation

W-L posit chemical and nuclear processes coexist in many systems

Key point: LENR transmutation processes can mimic a chemical fractionation

Please recall the basic equation for fractionation:

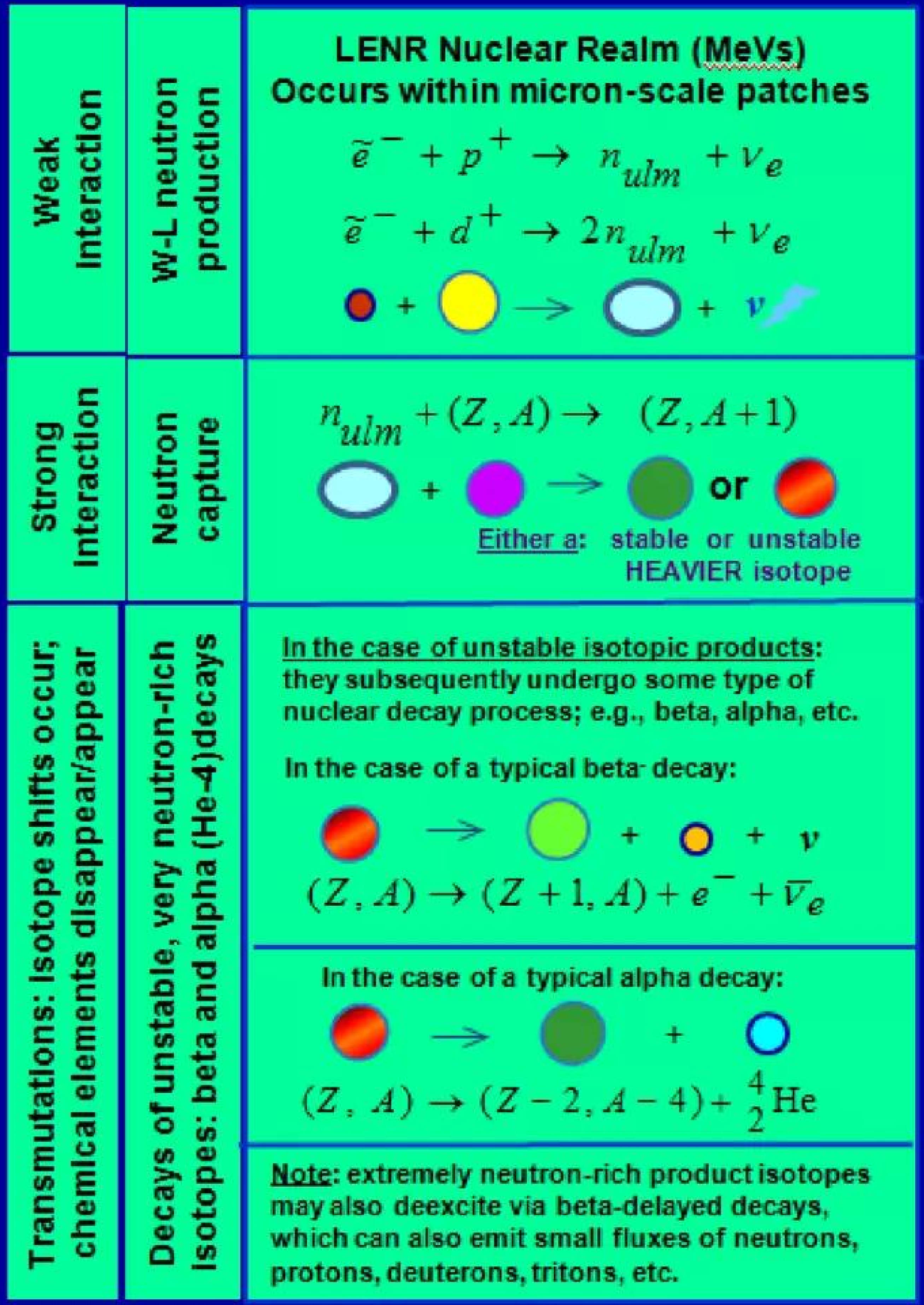
$$f = \frac{(heavy\ /\ light)\text{product}}{(heavy\ /\ light)\text{reactant}}$$

Now let us assume that in an idealized system:

- ✓ Purely chemical reactions occur at specific types of surface sites that range in size from <1 nanometer (nm) up to say ~100 microns
- ✓ ULM neutron-catalyzed transmutation reactions also occur on small length scales at a much smaller number of widely scattered sites on the very same surfaces; dimensions of such LENR-active sites can also range from <1 nm up to perhaps ~100 microns
- ✓ Some percentage of chemical product atoms are transported by ordinary physico-kinetic diffusion processes to spatially separated LENR-active sites where they then capture one or more LENR ULM neutrons; assume that newly produced heavier isotopes are stable

What has happened in this hypothetical example is that there has been an: (a) upward isotopic shift for some % of the product atoms; (b) increase in isotopic fractionation (i.e., larger value for the numerator)

Conclusion: transmutation processes can mimic chemical fractionation



Weak Interaction | **W-L neutron production**

LENR Nuclear Realm (MeVs)
Occurs within micron-scale patches

$$\tilde{e}^- + p^+ \rightarrow n_{ulm} + \nu_e$$

$$\tilde{e}^- + d^+ \rightarrow 2n_{ulm} + \nu_e$$

Strong Interaction | **Neutron capture**

$$n_{ulm} + (Z, A) \rightarrow (Z, A+1)$$

Either a: stable or unstable HEAVIER isotope

Transmutations: Isotope shifts occur; chemical elements disappear/appear | **Decays of unstable, very neutron-rich isotopes: beta and alpha (He-4) decays**

In the case of unstable isotopic products: they subsequently undergo some type of nuclear decay process; e.g., beta, alpha, etc.

In the case of a typical beta⁻ decay:

$$(Z, A) \rightarrow (Z+1, A) + e^- + \bar{\nu}_e$$

In the case of a typical alpha decay:

$$(Z, A) \rightarrow (Z-2, A-4) + {}^4_2\text{He}$$

Note: extremely neutron-rich product isotopes may also deexcite via beta-delayed decays, which can also emit small fluxes of neutrons, protons, deuterons, tritons, etc.

LENRs can mimic chemical fractionation

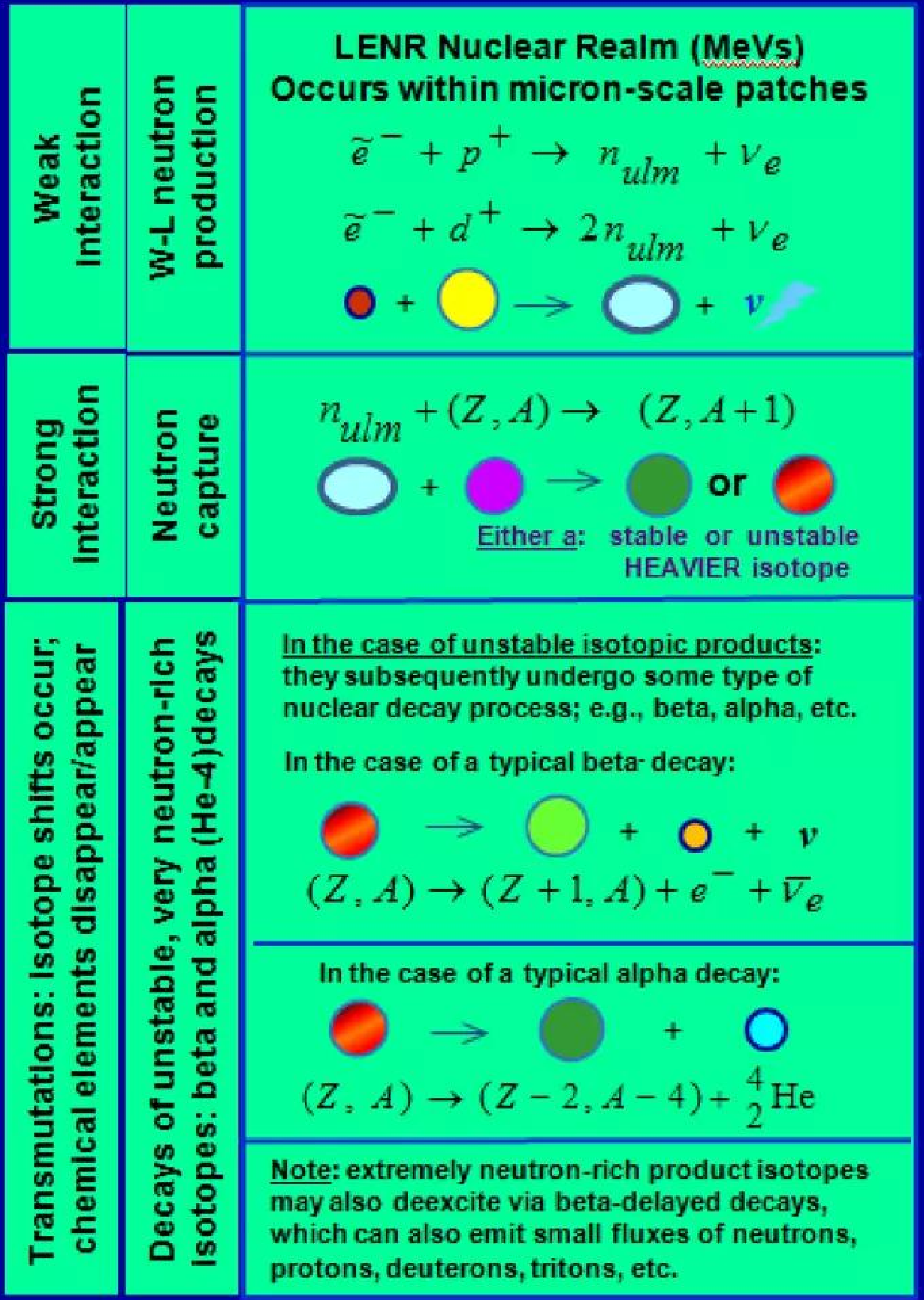
W-L posit chemical and nuclear processes coexist in many systems

Key point: LENR transmutation processes can mimic a chemical fractionation

Now please recall the methodology for calculating δ:

$$\delta = \left(\frac{R_{\text{sample}} - R_{\text{standard}}}{R_{\text{standard}}}\right) \text{x} 1000$$

In this methodology, the isotopic ratio R_{sample} measured in a sample is compared to an internationally agreed-upon reference standard; this approach is derived directly from the notion that there exists a time-invariant "natural isotopic abundance" for every stable element found on a given planet, e.g., earth. For example: in the case of hydrogen and oxygen isotopes, the commonly used standard is Standard Mean Ocean Water (SMOW), which represents an average 'global' value for the typical isotopic composition of ocean water. Results of such comparison-measurements are presented in what is called the delta (δ) notation (δ representing the measured difference between the isotopic composition of a given sample and a specific standard). A calculated δ value will be positive if a sample contains more of the specified heavy isotope than the standard; a δ value will be negative if a sample contains less of the heavy isotope than the standard. For many elements, δ values for isotopic composition are reported in per mille (‰), parts per thousands, rather than in percent (%)



Weak Interaction

W-L neutron production

LENR Nuclear Realm (MeVs)
Occurs within micron-scale patches

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In the case of a typical beta- decay:

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In the case of a typical alpha decay:

$$(Z, A) \rightarrow (Z-2, A-4) + {}^{4}_{2}\text{He}$$

Note: extremely neutron-rich product isotopes may also deexcite via beta-delayed decays, which can also emit small fluxes of neutrons, protons, deuterons, tritons, etc.

LENRs can mimic chemical fractionation

W-L posit chemical and nuclear processes coexist in many systems

LENR neutron captures on Oxygen can mimic a chemical fractionation process

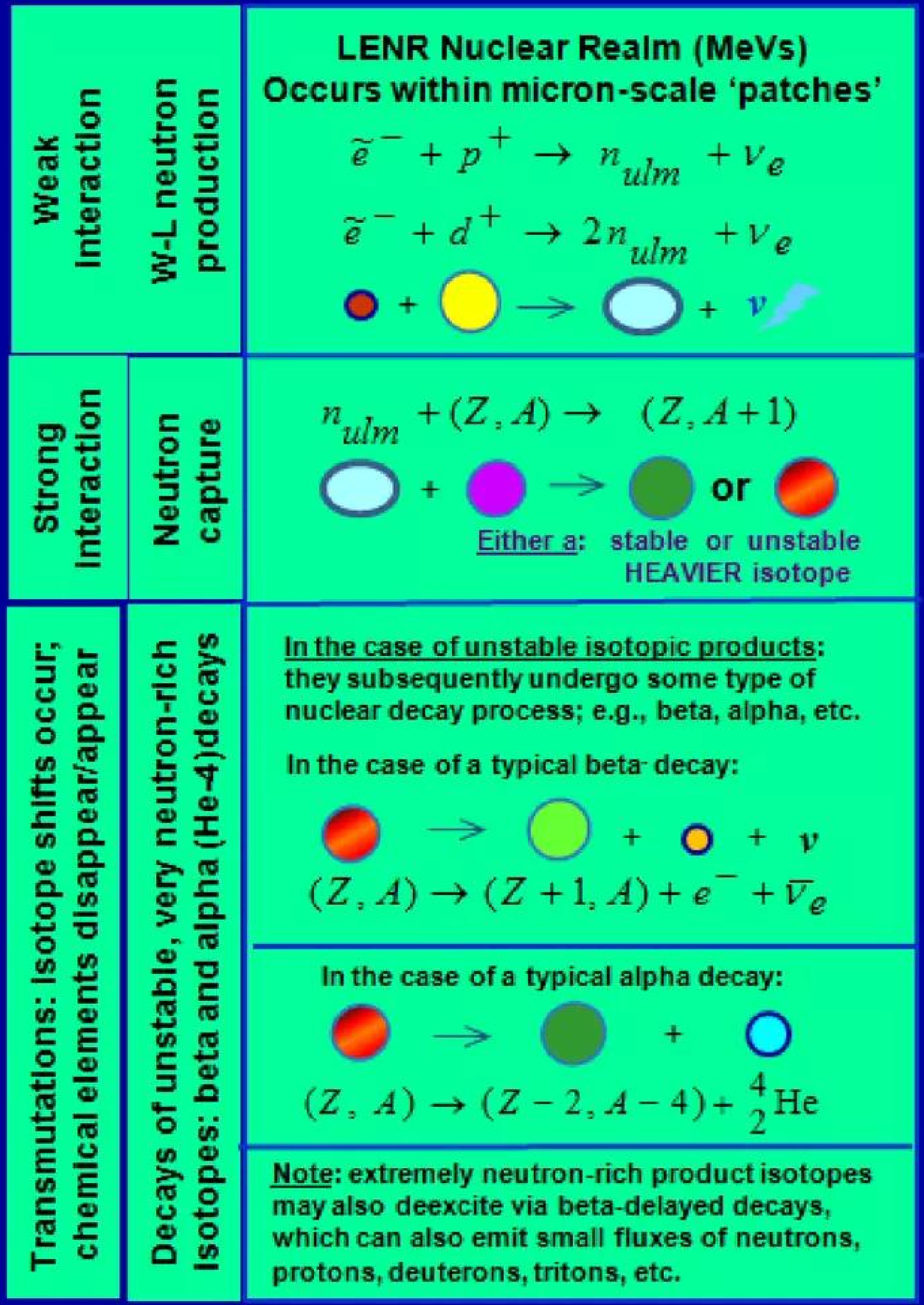
Now please recall the previous example for Oxygen:

$$\delta^{18}\mathrm{O} = \left[\frac{(^{18}\mathrm{O}/^{16}\mathrm{O})_{\mathrm{sam}} - (^{18}\mathrm{O}/^{16}\mathrm{O})_{\mathrm{SMOW}}}{(^{18}\mathrm{O}/^{16}\mathrm{O})_{\mathrm{SMOW}}} \right] \times 10^3$$

Natural abundance: ^{16}O = 99.759%; ^{17}O = 0.0374%; ^{18}O = 0.2039%

If ^{16}O were somehow exposed to fluxes of ULM neutrons: one might expect that it would first be transmuted via LENRs to ^{17}O with the capture of one ULM neutron. Now ^{17}O has the highest neutron capture cross-section of the three stable Oxygen isotopes (^{17}O = 0.54 millibarns for neutrons at thermal energies which is 2.8x that of ^{16}O and 3.4x ^{18}O), so $^{17}\mathrm{O} + n_{\mathrm{ulm}} \rightarrow {}^{18}\mathrm{O}$ would be favored. Also, Oxygen is an unusual lighter element in that ^{17}O just happens to have a significant cross-section for alpha decay upon capturing a neutron. Therefore, ^{17}O can be depleted in two ways by ULM neutron-catalyzed processes: (1.) neutron capture to ^{18}O; and (2.) alpha (^{4}He) decay to Carbon-14 (^{14}C). Those two competing processes are probably the reason why ^{17}O has a lower natural abundance than ^{16}O and ^{18}O

Thus, all other things being equal, repeated or protracted exposure of Oxygen atoms to ULM neutrons would likely tend to increase δ^{18}O



Weak Interaction

W-L neutron production

LENR Nuclear Realm (MeVs)
Occurs within micron-scale 'patches'

$$\tilde{e}^- + p^+ \rightarrow n_{ulm} + \nu_e$$

$$\tilde{e}^- + d^+ \rightarrow 2n_{ulm} + \nu_e$$

Strong Interaction

Neutron capture

$$n_{ulm} + (Z, A) \rightarrow (Z, A+1)$$

Either a: stable or unstable HEAVIER isotope

Transmutations: Isotope shifts occur; chemical elements disappear/appear

Decays of unstable, very neutron-rich isotopes: beta and alpha (He-4) decays

In the case of unstable isotopic products: they subsequently undergo some type of nuclear decay process; e.g., beta, alpha, etc.

In the case of a typical beta$^-$ decay:

$$(Z, A) \rightarrow (Z+1, A) + e^- + \bar{\nu}_e$$

In the case of a typical alpha decay:

$$(Z, A) \rightarrow (Z-2, A-4) + {}^4_2\mathrm{He}$$

Note: extremely neutron-rich product isotopes may also deexcite via beta-delayed decays, which can also emit small fluxes of neutrons, protons, deuterons, tritons, etc.

LENRs can mimic chemical fractionation

W-L posit chemical and nuclear processes coexist in many systems

Neutron captures on either H, C, N, and S can also mimic chemical fractionation

Hydrogen natural abundance: ^{1}H = 99.985%; ^{2}H (D; deuterium) = 0.015%

^{1}H has substantial capture cross-section for neutrons, 0.332 barns at thermal energies; this is ~650x capture c-s for D and >50,000x that for tritium (^{3}H). In LENR systems, $^1\text{H} + n \rightarrow {}^2\text{H} + \gamma$ the ~2.2 MeV gamma photon produced by ULM neutron capture on ^{1}H is directly converted to infrared (IR) photons by coupled heavy electrons; thus, no gamma emissions would be detected; if present, this reaction could produce increases in δD; note that ^{1}H is $1/v$ isotope

Carbon natural abundance: ^{12}C = 98.93%; ^{13}C = 1.07%

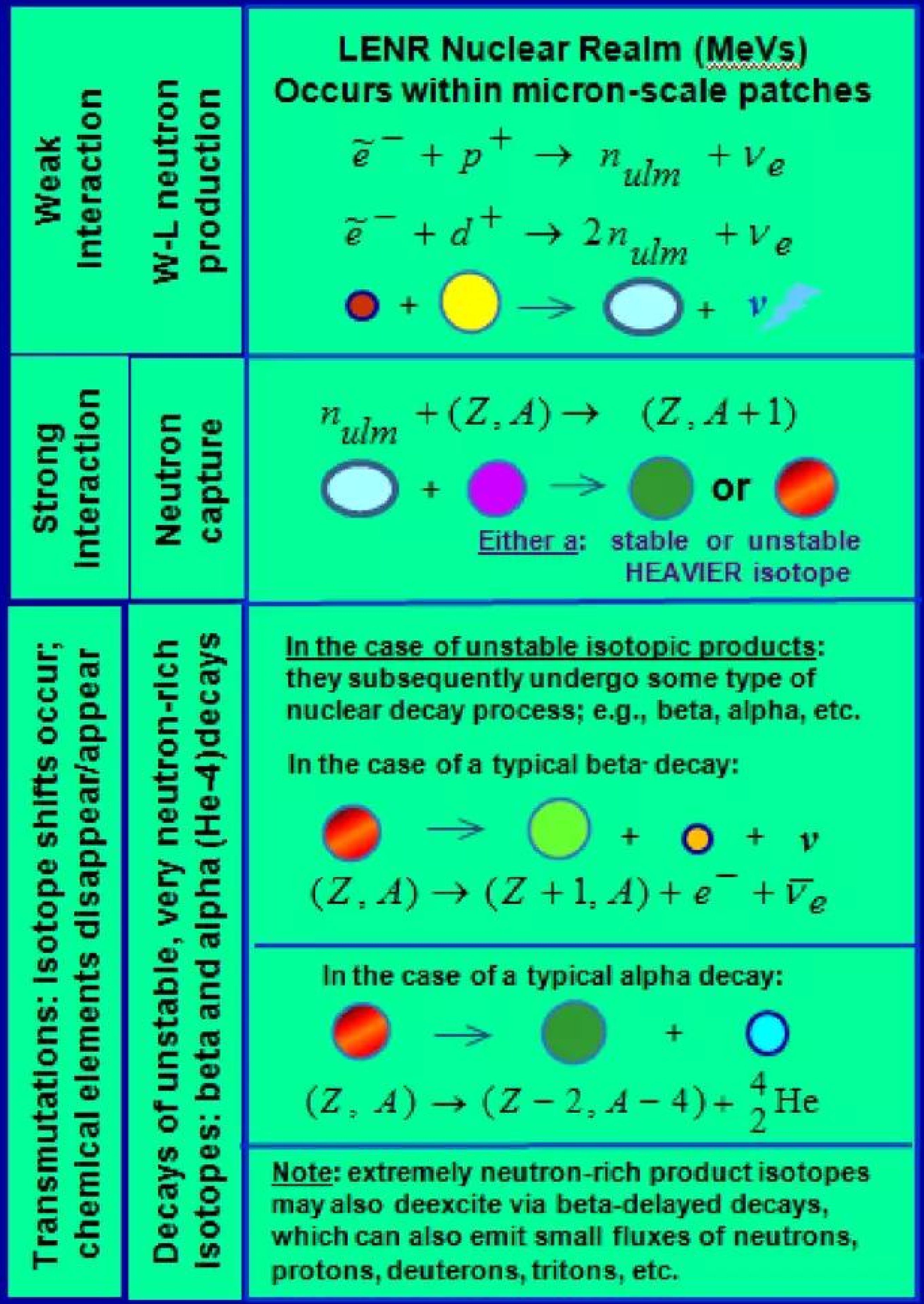
At thermal energies, ^{12}C has a neutron capture cross-section of only ~3.5 millibarns; at ULMN energies it is probably >3,000 barns since ^{12}C is a $1/v$ isotope. Thus, in LENR systems the reaction $^{12}\text{C} + n \rightarrow {}^{13}\text{C} + \gamma$ could in theory occur at substantial rates; again, capture gammas would not be detected because of their conversion to IR by mass- renormalized heavy electrons; at relatively low ULMN fluxes this reaction would most likely tend to increase δ^{13}C

Nitrogen natural abundance: ^{14}N = 99.632%; ^{15}N = 0.368%

At thermal energies, ^{14}N has a neutron capture cross-section of only 0.080 barns; at ULM energies it may be 10^5-10^6 larger because ^{14}N is $1/v$ isotope. Thus, in LENR systems the reaction $^{14}\text{N} + n \rightarrow {}^{15}\text{N} + \gamma$ can potentially occur at significant rates; again, capture gammas would not be detected because of conversion to IR by heavy electrons. ULMN capture on ^{15}N would produce ^{16}N which is unstable (half-life = 7.1 seconds) and beta decays into ^{16}O which is stable. Thermal neutron capture cross-section for ^{15}N is 2,000x less than ^{15}N; all other things being equal, at low ULM neutron fluxes ^{15}N should accumulate faster than it can be transmuted via neutron capture into ^{16}N; altogether, these reactions would likely tend to produce increases in δ^{15}N

Sulfur natural abundance: ^{32}S = 94.93%; ^{33}S = 0.76%; ^{34}S = 4.29%; ^{36}S = 0.02%

Beginning with ^{32}S, Sulfur's four stable isotopes have similar thermal neutron capture cross-sections of 0.55, 0.46, 0.30, and 0.23 barns, respectively; they are all $1/v$ isotopes. All other things being equal, at low ULM neutron fluxes, δ^{33}S, δ^{34}S, and δ^{36}S would all tend to increase; ^{35}S is unstable (h-l = 87 days) and beta decays to ^{35}Cl. Higher ULMN fluxes would produce ^{37}S which is unstable (h-l = 5.1 minutes) and β^- decays into Chlorine ^{37}Cl (stable but very reactive)



LENR Nuclear Realm (MeVs)
Occurs within micron-scale patches

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LENRs can mimic chemical fractionation

W-L posit chemical and nuclear processes coexist in many systems

LENR transmutations on catalyst surfaces can also mimic chemical fractionation

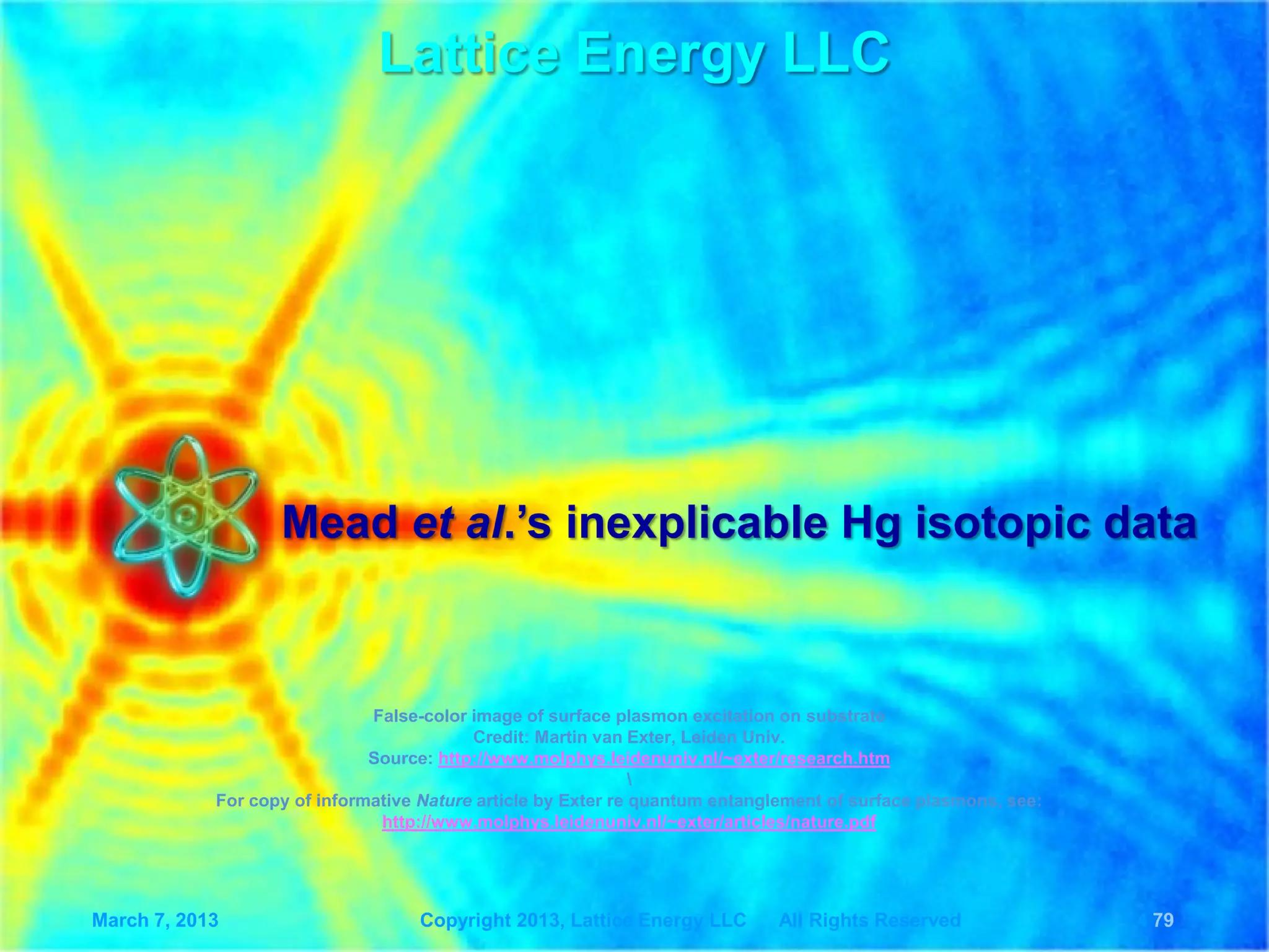
In most chemical catalysis, reactants and products must be in intimate nanoscale contact with a surface (often a metal of some sort) in order for a catalytic acceleration of reaction rates to occur. Interestingly, the following three reactions are all well-known to be catalyzed by Palladium (Pd), Pt, and/or Rh and are important in truck and automobile catalytic converters:

$2NO_x \rightarrow xO_2 + N_2$ $\quad$ $2CO + O_2 \rightarrow 2CO_2$ $\quad$ $C_xH_{2x+2} + [(3x+1)/2]O_2 \rightarrow xCO_2 + (x+1)H_2O$

Hypothetically, what might occur if such reactions took place at tiny sites on a catalyst surface that also just happened to be located right on the edge of a 30 micron patch in which fluxes of LENR ULM neutrons were being produced? Well, according to the W-L theory all the atoms comprising any of the reactants (which are not necessarily 100% consumed) or products found in such locations would have an opportunity to compete (with many thousands of other atoms located in and adjacent to the patch) to capture ULM neutrons. At low fluxes, typically only one ULM neutron might be captured by a given target atom. That would tend to deplete lower-mass isotopes and enrich higher-mass isotopes; i.e., in above examples one could conjecture that δ^{5}N, δ^{18}O, δ^{13}C and δD would all increase as if they had been fractionated

All other things being equal, repeated or protracted exposure of molecular H, C, N, O, or S atoms to local fluxes of ULM neutrons would most likely tend to increase measured values for δD, δ^{13}C, δ^{15}N, δ^{17-18}O, and δ^{34}S; such LENR nuclear effects would be manifested as statistically significant variances from reference standards. At relatively low ULM neutron fluxes, LENRs might very well mimic mass-dependent chemical fractionation processes. At somewhat higher fluxes of captured neutrons, LENRs could potentially produce significantly larger stable isotope anomalies that would very likely exhibit no apparent relationship to isotopic mass; i.e., they would appear to be mass-independent

At high local ULM neutron fluxes, several neutrons might be captured by a particular atom, creating an unstable, neutron-rich heavy isotope that beta decays, producing a different chemical element which would then be available to participate locally in other chemical reactions. Such newly produced stable elements, which may or not have been previously present before (say) an experiment began, could mistakenly be regarded by researchers as being ‘outside contaminants’ when they are really products of local LENR transmutation processes



Mead *et al*.’s inexplicable Hg isotopic data

False-color image of surface plasmon excitation on substrate
Credit: Martin van Exter, Leiden Univ.
Source: http://www.molphys.leidenuniv.nl/~exter/research.htm
\
For copy of informative *Nature* article by Exter re quantum entanglement of surface plasmons, see:
http://www.molphys.leidenuniv.nl/~exter/articles/nature.pdf

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Mead *et al.*'s inexplicable Hg isotopic data

Widom-Larsen theory of LENRs can explain all this anomalous data

Data collected over 100 years suggests transmutations in electric discharges

- ✓ As we outlined in the Historical Perspective section herein: for over 100 years researchers working in a broad range of scientific disciplines have episodically published experimental data in peer-reviewed journals which strongly suggests that nuclear transmutations are occurring in many different types of electrical discharges
- ✓ In laboratory experiments: discharges may involve high- or low-currents, high- or low-voltages, with or without overt macroscopic electrical arcing that can take place in air, various gases, in ideal or dusty plasmas, as well as in liquid water, electrolytes, or in hydrocarbon liquids. In Nature: since 1985, published data has been accumulating showing neutron production in lightning bolts, which would cause transmutations when produced neutrons are captured by elements present in nearby molecules
- ✓ In the early days of such experiments with electrical arcs in gases, presumed nuclear transmutation products were mainly detected via analysis of line spectra; e.g., Wendt & Irion (1922), Gaschler (1924), Nagaoka (1925), Thomassen (1927), etc.
- ✓ More recently, possible discharge-related transmutation products were detected using a plethora of different, modern mass spectroscopy techniques that include: ICP-MS, SIMS, NAA, SEM-EDX, EDX, and XPS among others; e.g., Iwamura *et al*. (2012), and Mead *et al.* (2013) that we will shortly discuss herein

Mead *et al.*'s inexplicable Hg isotopic data

Widom-Larsen theory of LENRs can explain all this anomalous data

Many different electric discharge experiments have somehow involved Hg and W

- ✓ **According to Widom-Larsen theory: experimental or natural systems in which elemental Mercury (Hg) and/or Tungsten are involved with or in close physical proximity to electrical discharges where Hydrogen (i.e., a proton source) is also present nearby in some form, can potentially produce neutrons locally via an electroweak $e^{+} + p^{+}$ reaction**
- ✓ **Since they would mostly be super low-energy, such collectively produced neutrons will be captured locally on elements present in nearby materials, including Mercury and Tungsten. Over time, this ongoing process of neutron production, captures, and nuclear decays will create a complex, temporally evolving neutron-catalyzed LENR transmutation network such as the hypothetical examples we have discussed herein**
- ✓ **To assess the explanatory utility and validity of our theoretically-driven conceptual model for LENR transmutations in such systems: we have sought to find published, peer-reviewed experimental data involving electric discharges involving Tungsten, Mercury, or any other elements found in the hypothesized W-L LENR network that could serve as capture targets in which: (a) significant isotopic shifts were observed that (b) cannot be easily explained by just invoking prosaic chemical fractionation processes**
- ✓ **These criteria are satisfied in the 2013 paper by Mead *et al*. which we will now discuss after we review recently reported data that supports the idea of W-target LENR network**

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Mead *et al.*'s inexplicable Hg isotopic data

Experimental data supports concept of a W-target LENR network

Nuclear products of Tungsten targets follow network pathway predicted by W-L

Key segments of this hypothesized LENR transmutation network been effectively confirmed in data from at least three sets of published laboratory experiments that differ significantly in experimental techniques but nonetheless involve exactly the same underlying Widom-Larsen nucleosynthetic process and LENR network pathway: W → Re → Os → Ir → Pt → Au

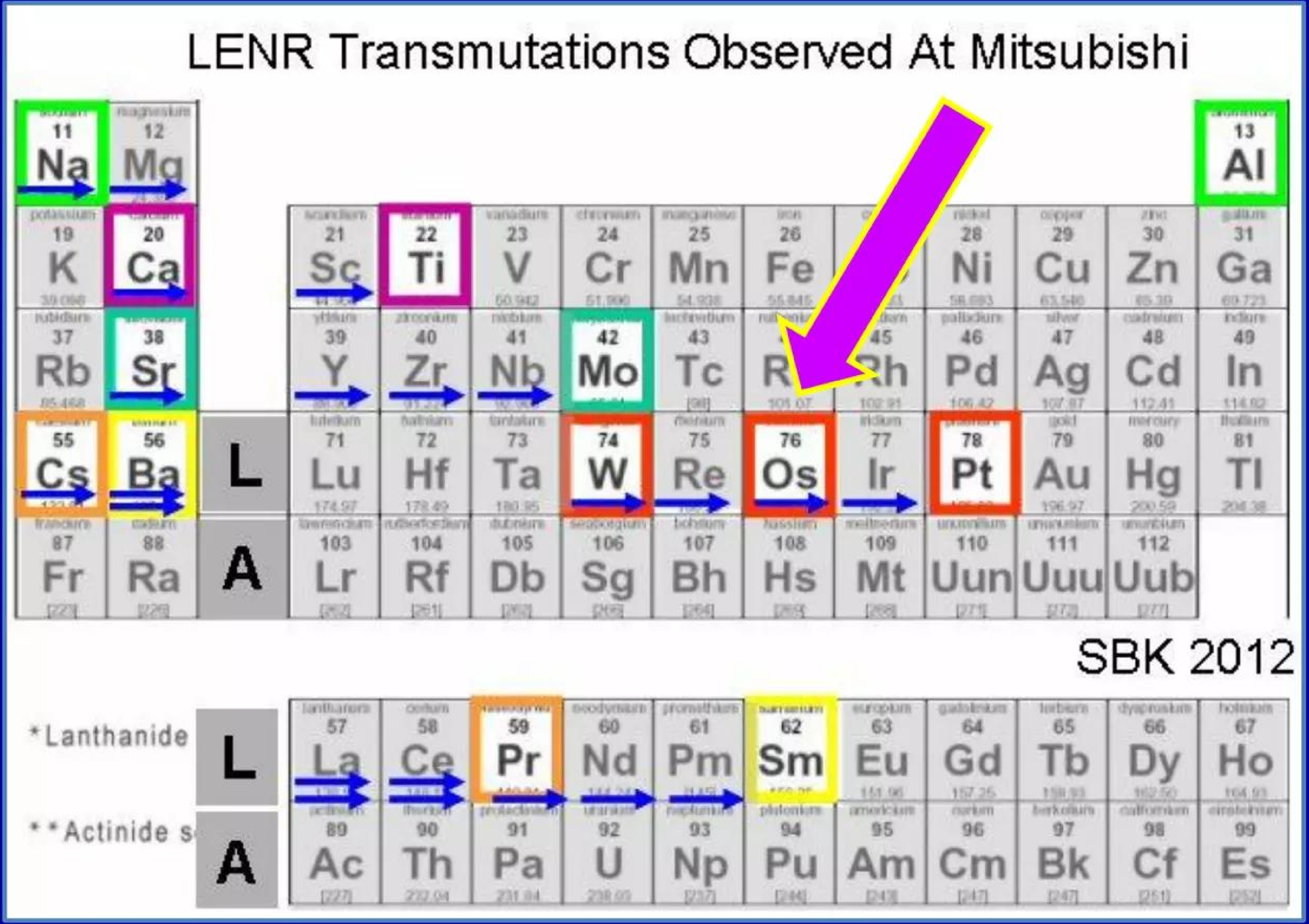
See documents concerning ANS Winter meeting LENR session held on November 14, 2012:

- ✓ **Dec. 7, 2012: *New Energy Times* article by Steven Krivit article about this session (substantial part of its entire content is subscriber-only), titled, *"*Mitsubishi Reports Toyota Replication*"* http://news.newenergytimes.net/2012/12/06/mitsubishi-reports-toyota-replication/**
- ✓ **Dr. Yasuhiro Iwamura's 44-slide PowerPoint for presentation (free content - see Slides #26 - 29): http://newenergytimes.com/v2/conferences/2012/ANS2012W/2012Iwamura-ANS-LENR.pdf**
- ✓ **Iwamura's related 4-page paper published in *Transactions of the ANS* (free content - see page #3 just under Fig. 6 "SIMS Analysis for W Transmutation Expts"; note: cites 2006 W&L *EPJC* paper): http://newenergytimes.com/v2/conferences/2012/ANS2012W/2012Iwamura-ANS-LENR-Paper.pdf**
- ✓ **Online YouTube video for viewing Iwamura's live presentation at the ANS meeting (free content): http://youtu.be/VefCEaLAkRw (running time is ~43 minutes; Dr. Iwamura's English is excellent)**

Mead *et al.*'s inexplicable Hg isotopic data

November 2012 ANS Winter meeting: Mitsubishi reported new data

Nuclear products of Tungsten targets followed the pathway predicted by W-L


LENR Transmutations Observed At Mitsubishi

SBK 2012

Source of adapted graphic is *New Energy Times*: http://news.newenergytimes.net/2012/12/06/mitsubishi-reports-toyota-replication/

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Mead *et al.*'s inexplicable Hg isotopic data

November 2012 ANS Winter meeting: comments re Mitsubishi's data

Were unable to go all the way to Gold because their neutron fluxes were too low

- ✓ Technical comments: permeation technique used by Iwamura *et al.* in experiments with Tungsten (W) targets produces relatively small fluxes of ultra low momentum LENR neutrons; their electroweak neutron production rate was therefore insufficient to drive the W-L LENR transmutation network all the way out to the stable Gold isotope during elapsed time of the experiments - only got as far as Platinum (Pt), which was observed
- ✓ Please carefully examine data found in PowerPoint slides, related paper published in ANS *Transactions*, and video of Dr. Iwamura's Nov. 14, 2012, ANS meeting presentation
- ✓ While Mitsubishi's carefully conducted LENR experiments did not reach Gold, they did observe some of the predicted intermediate products, namely Osmium and Platinum
- ✓ Since Cirillo and Nagaoka's experiments had much higher levels of input energy in the form of electric currents, per W-L theory they would be expected to produce higher neutron fluxes and progress further into the LENR network: in fact, they did reach Gold
- ✓ Quoting directly from *New Energy Times* subscriber-only content concerning 2012 Winter ANS meeting, "A member of the audience asked Dr. Iwamura whether other Japanese companies besides Toyota and Mitsubishi are working on LENR. Iwamura said yes but they were not disclosing it." These companies are serious LENR players

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Mead *et al.*'s inexplicable Hg isotopic data

Is this LENR network operating in Mead *et al.*'s CFL system?

Diagram only shows Mercury (Hg) segment of LENR transmutation network


ε 600 keV BR = 100%

$_{80}$Hg-196 Stable 0.15%

6.8

$_{80}$Hg-197 HL = 2.7 days

8.5

$_{80}$Hg-198 Stable 9.8%

6.7

$_{80}$Hg-199 Stable 16.9%

8.0

$_{80}$Hg-200 Stable 23.1%

6.2

$_{80}$Hg-201 Stable 13.2%

7.8

$_{80}$Hg-202 Stable 29.9%

6.0

$_{80}$Hg-203 HL= 46.6 days

492 keV

7.5

$_{80}$Hg-204 Stable 6.9%

5.7

Note: it only costs 0.78 MeV to produce a neutron, so single neutron captures shown above provide a good net energy-gain

Legend

Neutron capture and nuclear decay processes:

ULM neutron captures proceed from left to right; Q-value of capture reaction (MeV) in **green** either above or below horizontal arrow.

Beta$^-$ (β^-) decays proceed from top to bottom; denoted with bright **blue** vertical arrow pointing down with Q-value (MeV) in **blue** either to left or right; **beta$^+$ (β^+) decays** are denoted with **yellow** arrow pointing upward to row above

Electron captures (e.c.) indicated by **purple** vertical arrow; **Q-value (MeV)** to left or right.

Note: to reduce visual clutter in the network diagram, gamma emissions (converted to infrared photons by heavy e^{-*} electrons) are not shown; similarly, except where specifically listed because a given branch cross-section is significant, beta-delayed decays also generally not shown; BR means "branching ratio" if >1 decay alternative

Color coded half-lives:

When known, half-lives shown as "HL = xx". Stable and quasi-stable isotopes (i.e., those with half-lives > or equal to 10^7 years) indicated by **green** boxes; isotopes with half-lives < 10^7 but > than or equal to 10^3 years indicated by **light blue**; those with half-lives < than 10^3 years but > or equal to 1 day are denoted by **purplish** boxes; half-lives of < 1 day in yellow; with regard to half-life, notation "? nm" means isotope has been verified by HL has not been measured

Measured natural terrestrial abundances for stable isotopes:

Indicated with % symbol; note that $_{83}$Bi^{209} = 100% (essentially ~stable with half-life = 1.9 x 10^{19} yrs); $_{82}$Pb-205 ~stable with HL= 1.5 x10^7 yrs;

Mercury Isotopes Data

Isotope	Natural Abundance If unstable, half-life is provided	Thermal neutron capture cross-section (barns)
^{196}Hg	0.150%	105
^{197}Hg	H.L. = 2.7 days	NA
^{198}Hg	9.8%	0.017
^{199}Hg	16.9%	2.1 x 10^3
^{200}Hg	23.1%	<60
^{201}Hg	13.2%	<60
^{202}Hg	29.9%	4.9
^{203}Hg	H.L. = 46.6 days	NA
^{204}Hg	6.9%	0.400

Mead *et al.*'s inexplicable Hg isotopic data

In 2013 Mead *et al.* reported anomalous Hg isotopic shifts in CFLs

Admit some of their data hard to explain with a chemical fractionation process

"Unique Hg stable isotope signatures of compact fluorescent lamp-sourced Hg"
C. Mead, J. Lyons, T. Johnson, and D. Anbar
***Environmental Science & Technology* DOI: 10.1021/es303940p (web: February 4, 2013)**
http://pubs.acs.org/doi/abs/10.1021/es303940p [e-cost is US$35.00 for non-subscribers]

Quoting abstract directly:

"The recent widespread adoption of compact fluorescent lamps (CFL) has increased their importance as a source of environmental Hg. Stable isotope analysis can identify the sources of environmental Hg, but the isotopic composition of Hg from CFL is not yet known. Results from analyses of CFL with a range of hours of use show that the Hg they contain is isotopically fractionated in a unique pattern during normal CFL operation. This fractionation is large by comparison to other known fractionating processes for Hg and has a distinctive, mass-independent signature, such that CFL Hg could be uniquely identified from other sources. The fractionation process described here may also explain anomalous fractionation of Hg isotopes in precipitation."

Lattice Energy LLC

Mead *et al.*'s inexplicable Hg isotopic data

In 2013 Mead *et al*. reported anomalous Hg isotopic shifts in CFLs

Admit some of their data hard to explain with a chemical fractionation process

Direct quotes selected from body of paper:

"Trapped Hg of used CFL show unusually large isotopic fractionation, the pattern of which is entirely different from that which has been observed in previous Hg isotope research aside from intentional isotope enrichment. Most notably, there is no straightforward relationship between extent of fractionation and isotope mass. Thus, while previous studies of MIF of Hg only observed large deviations from mass-dependence in odd mass isotopes, our results clearly show MIF across multiple even mass and odd mass isotopes."

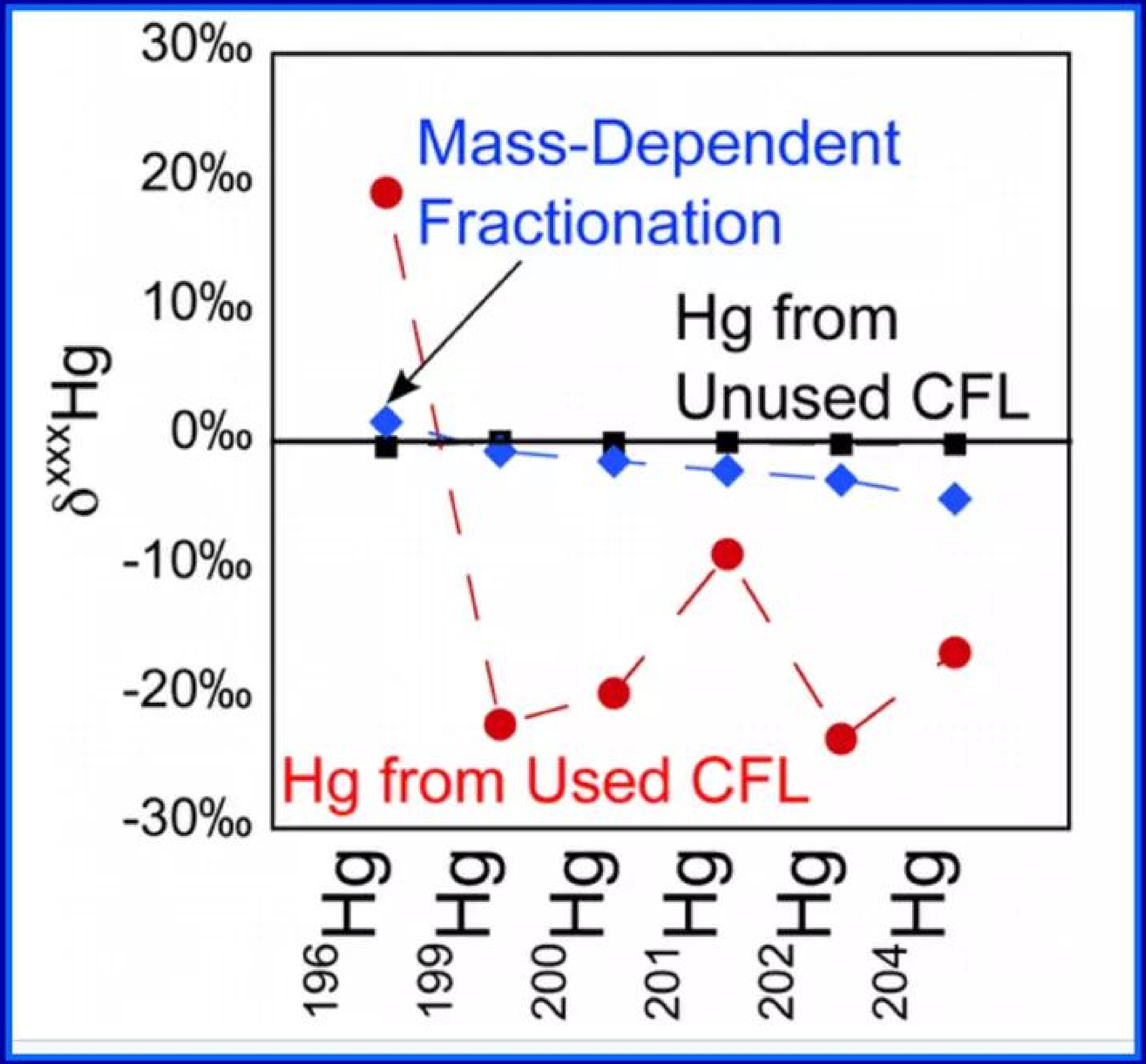
Lattice comments:

Please note our earlier discussion herein where we showed how operation of LENRs can potentially mimic the isotopic effects of both mass-dependent (MDF) and so-called mass-independent (MIF) isotopic fractionation processes.

Also note, as we said earlier, it is NOT an all-or-nothing choice between chemical vs. nuclear conceptual paradigms to explain anomalous isotopic data; we strongly believe that both types of isotope shifting processes can happily coexist within the same system and perhaps even on the same surface or interface. In our view, the task of researchers is to accurately assess how much each process might be contributing to shifts in different isotopes

Large Isotopic shifts were observed:

Fig. shows large deviations from MDF and unused samples



Source: webpage at http://pubs.acs.org/doi/abs/10.1021/es303940p

Lattice Energy LLC

Mead *et al.*'s inexplicable Hg isotopic data

In 2013 Mead *et al*. reported anomalous Hg isotopic shifts in CFLs

Admit some of their data hard to explain with a chemical fractionation process

Lattice further comments:

- ✓ Highly successful earlier electric discharge LENR transmutation experiments mentioned herein, including exploding wires, generally utilized relatively high currents and in some cases used current pulses with very fast rise-times on the order of <200 nanoseconds in conjunction with abundant quantities of hydrogen (protons) locally present in some molecular form, e.g., Nagaoka et al. as described herein (Japan - 1925) and Cirillo *et al*. (Italy - 2011), who used a glow-discharge aqueous electrolytic chemical cell for their experimental system

- ✓ In some experiments only modest temperatures and pressures were used to trigger LENRs --- no electric current --- e.g., Iwamura *et al*. (Japan - 2012); in those cases only tiny fluxes of neutrons were likely produced and consequently only small segments of the entire LENR transmutation network could be explored, i.e., Iwamura *et al*. were unable to create Au, whereas Nagaoka and Cirillo were able to achieve detectable Gold production (Au only has one stable isotope)

- ✓ In case of the compact fluorescent lights (CFLs) used in Mead *et al.*'s electric discharge experiments, electric input currents were relatively modest compared to most of the above-described earlier LENR experiments and hydrogen (protons) could well be in short-supply inside e CFL tubes (this issue will be discussed in greater detail shortly). Therefore, rates of ULM neutron production in Mead *et al.*'s CF lights are very likely to be extremely low. That said, if LENRs are truly occurring in CFLs, modern mass spectroscopy may be able to detect their presence if CFL devices have been operated for long-enough to accumulate observable transmutation products

Lattice Energy LLC

Mead *et al*.'s inexplicable Hg isotopic data

In 2013 Mead *et al*. reported anomalous Hg isotopic shifts in CFLs

Background and description of their experimental system

Quoting directly from the body of their paper:

"Previous research demonstrated that in addition to producing light, photoexcitation of Hg vapor within FL causes a small fraction of that Hg to become trapped in the glass wall over the lifetime of the lamp. This one-way transport preserves the isotopic fractionation between the trapped Hg and the vapor by preventing any re-equilibration. Hg exists in a number of forms within a FL (Figure 1). A Hg amalgam pellet serves as the primary reservoir, with a small amount of Hg vapor present in equilibrium with the amalgam. Less than 1% of the total Hg in the lamp leaves the vapor phase and becomes adsorbed to the interior of the lamp, and a similar amount becomes trapped within the glass wall."

"Light is generated by exciting the Hg vapor with an electric current. When the Hg atoms return to their ground state, they emit a characteristic UV photon, which is absorbed by the phosphor powder at the lamp wall. The phosphor then re-emits visible light."

"For this study, we analyzed the Hg isotope composition of compact fluorescent lamps (CFL) used for known numbers of hours to determine whether Hg trapped in their glass walls is isotopically fractionated from the main reservoir of Hg and, if so, whether this fractionation is distinct from that of previously measured sources of environmental Hg. The CFL Hg was divided into two components for analysis: (1) the trapped Hg (i.e., Hg contained within the glass matrix) and (2) the bulk Hg (i.e., the combination of the Hg amalgam pellet, Hg vapor, and adsorbed Hg). We also measured whole-lamp Hg (bulk Hg + trapped Hg), which provides a complete account of all Hg contained within the lamp."

Quoting from their Materials and Methods:

"The CFL used in this study were taken from a single box of 14-W consumer lamps (EcoSmart, Home Depot part #785800). Three were retained in unused condition. The others were used continuously for 1700, 3600, 10000 or 16000 h. The rated lifetime of the lamps is 10000 h. To determine the composition of the trapped Hg, a lamp was broken, the amalgam pellet was removed, and the glass was placed in an HDPE container with 100 mL 10% HNO_3 for one week to remove adsorbed Hg." Samples were further treated and then analyzed with a mass spectrometer.

"Isotope ratio measurements were made using a Neptune (Thermo Elemental) multicollector inductively coupled plasma mass spectrometer. A custom-made cold vapor system was used for sample introduction."

"Isotope data are reported in permil (‰) relative to NIST SRM-3133 using delta notation: δ^{xxx}Hg = (^{xxx}Hg/198Hg_{sample})/(^{xxx}Hg/^{198}HgSRM-3133) − 1, where xxx denotes the mass of each respective isotope. The "cap-delta" notation is defined: Δ^{xxx}Hg = ln(δ^{xxx}Hg + 1) − X ln(δ202Hg + 1), where X is −0.5074, 0.2520, 0.5024, 0.7520, or 1.493 for ^{196}Hg, ^{199}Hg, ^{200}Hg, ^{201}Hg, or ^{204}Hg, respectively. This scaling factor is equal to the relative amount of MDF experienced by each isotope pair, such that cap-delta is zero when only MDF is present."

"Due to the large and unusual fractionation that was observed, extensive checks were performed to rule out possible analytical artifacts."

Mead *et al.*'s inexplicable Hg isotopic data

Key: Mead *et al.* do not measure Hg mass balance within a single lamp

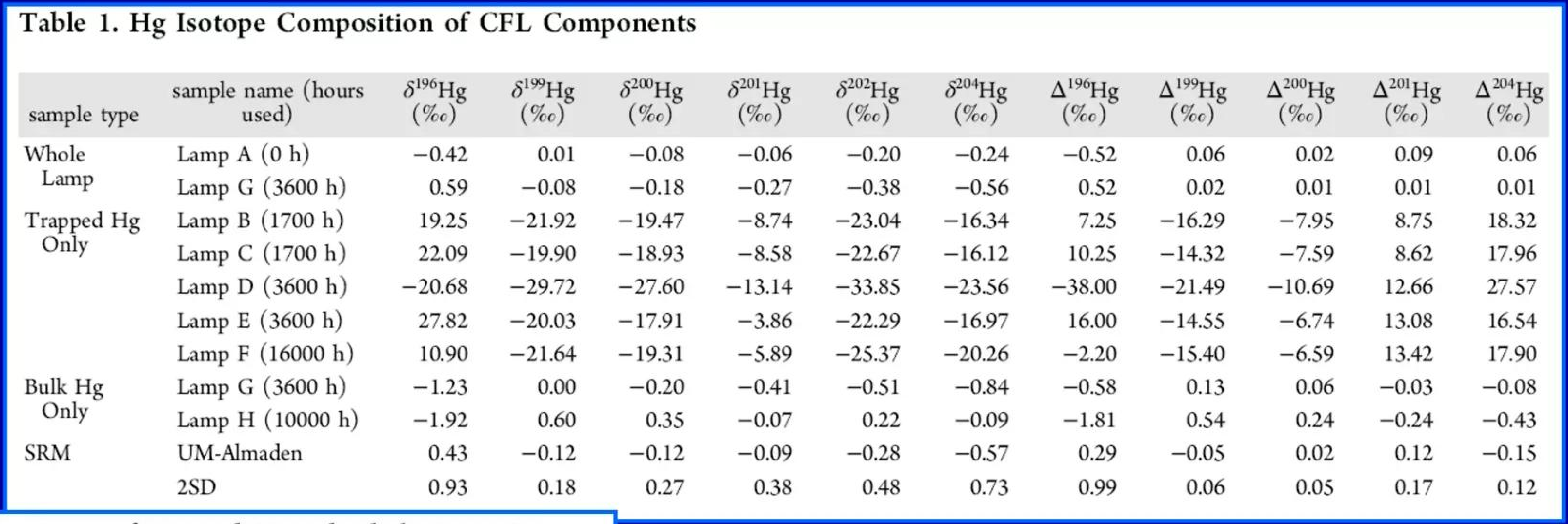


Table 1. Hg Isotope Composition of CFL Components

sample type	sample name (hours used)	δ^{196}Hg (‰)	δ^{199}Hg (‰)	δ^{200}Hg (‰)	δ^{201}Hg (‰)	δ^{202}Hg (‰)	δ^{204}Hg (‰)	Δ^{196}Hg (‰)	Δ^{199}Hg (‰)	Δ^{200}Hg (‰)	Δ^{201}Hg (‰)	Δ^{204}Hg (‰)
Whole Lamp	Lamp A (0 h)	−0.42	0.01	−0.08	−0.06	−0.20	−0.24	−0.52	0.06	0.02	0.09	0.06
	Lamp G (3600 h)	0.59	−0.08	−0.18	−0.27	−0.38	−0.56	0.52	0.02	0.01	0.01	0.01
Trapped Hg Only	Lamp B (1700 h)	19.25	−21.92	−19.47	−8.74	−23.04	−16.34	7.25	−16.29	−7.95	8.75	18.32
	Lamp C (1700 h)	22.09	−19.90	−18.93	−8.58	−22.67	−16.12	10.25	−14.32	−7.59	8.62	17.96
	Lamp D (3600 h)	−20.68	−29.72	−27.60	−13.14	−33.85	−23.56	−38.00	−21.49	−10.69	12.66	27.57
	Lamp E (3600 h)	27.82	−20.03	−17.91	−3.86	−22.29	−16.97	16.00	−14.55	−6.74	13.08	16.54
	Lamp F (16000 h)	10.90	−21.64	−19.31	−5.89	−25.37	−20.26	−2.20	−15.40	−6.59	13.42	17.90
Bulk Hg Only	Lamp G (3600 h)	−1.23	0.00	−0.20	−0.41	−0.51	−0.84	−0.58	0.13	0.06	−0.03	−0.08
	Lamp H (10000 h)	−1.92	0.60	0.35	−0.07	0.22	−0.09	−1.81	0.54	0.24	−0.24	−0.43
SRM	UM-Almaden	0.43	−0.12	−0.12	−0.09	−0.28	−0.57	0.29	−0.05	0.02	0.12	−0.15
	2SD	0.93	0.18	0.27	0.38	0.48	0.73	0.99	0.06	0.05	0.17	0.12

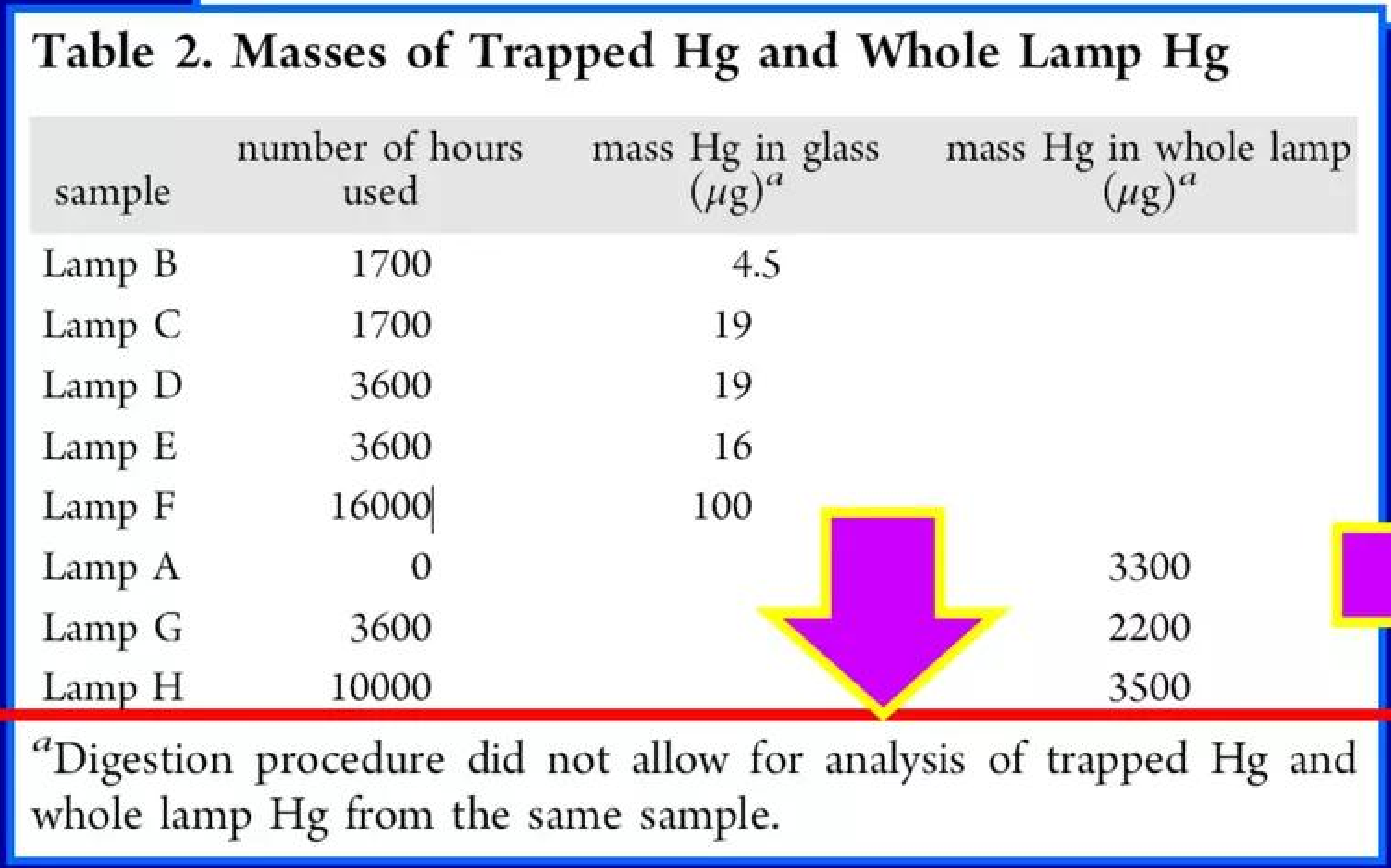


Table 2. Masses of Trapped Hg and Whole Lamp Hg

sample	number of hours used	mass Hg in glass (μg)[a]	mass Hg in whole lamp (μg)[a]
Lamp B	1700	4.5	
Lamp C	1700	19	
Lamp D	3600	19	
Lamp E	3600	16	
Lamp F	16000	100	
Lamp A	0		3300
Lamp G	3600		2200
Lamp H	10000		3500

[a] Digestion procedure did not allow for analysis of trapped Hg and whole lamp Hg from the same sample.

Source: Mead *et al.* (2013)

Quoting from Mead *et al.*'s discussion:

"Our method of isolating the two reservoirs did not allow analysis of both reservoirs within a single lamp, so the data shown are for multiple lamps spanning a range of hours of use."

Comment:

This is a key point --- they do not measure any true mass balance *within a single lamp*. Therefore, if a potentially measurable amount of Hg had hypothetically been transmuted to another element (e.g., Tl or Pb) they wouldn't see any discrepancies in mass balance data simply because of the way they measure it experimentally

Lattice Energy LLC

Mead *et al.*'s inexplicable Hg isotopic data

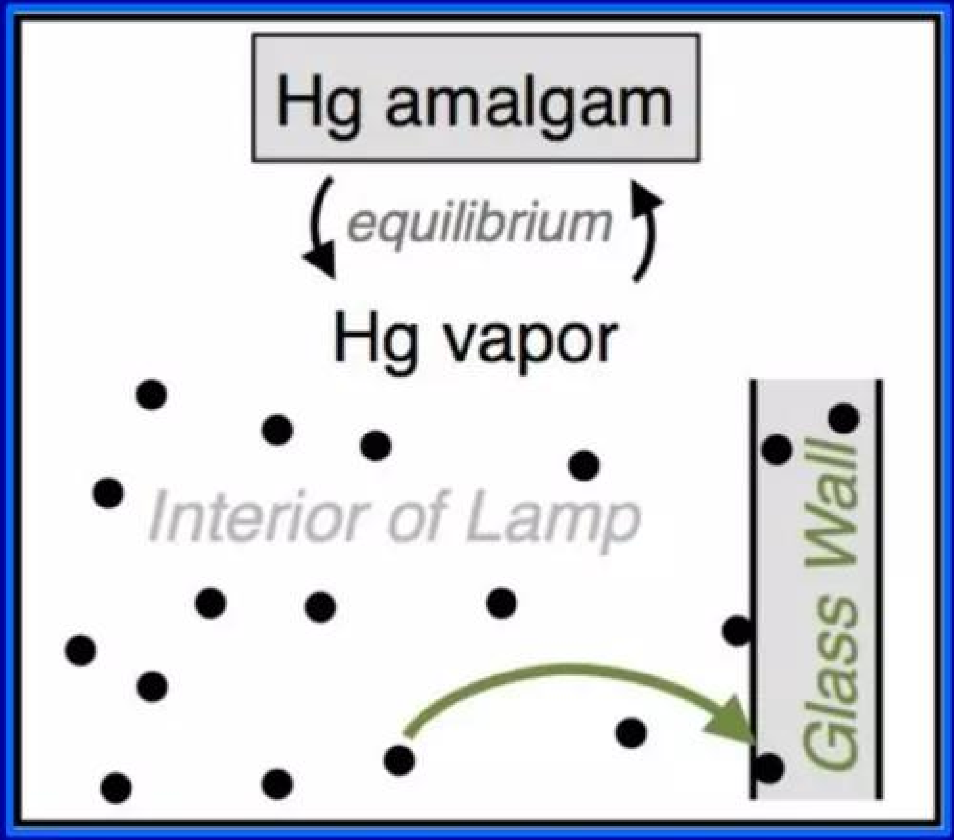
Admit some data hard to explain with a chemical fractionation process

Quoting directly from the body of their paper:

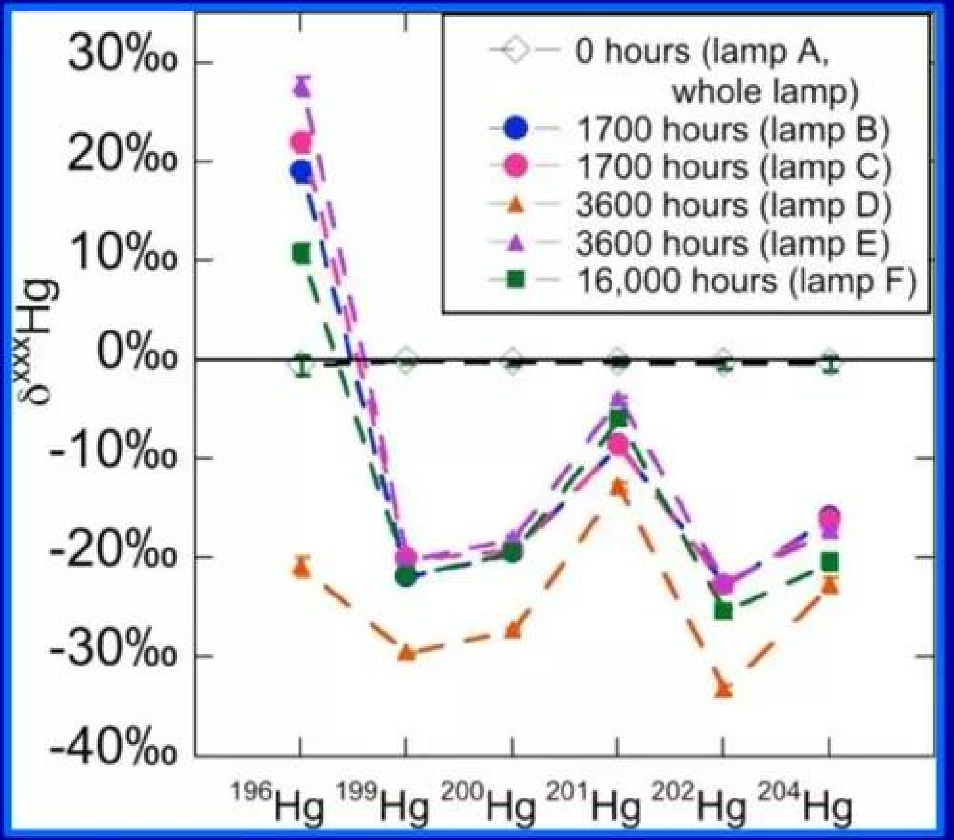
"The trapped Hg of used CFL show unusually large isotopic fractionation (Figure 2, Table 1), the pattern of which is entirely different from what has been observed in previous Hg isotope research aside from intentional isotope enrichment. Most notably, there is no straightforward relationship between extent of fractionation and isotope mass. Thus, while previous studies of MIF of Hg only observed large deviations from mass-dependence in odd mass isotopes, our results clearly show MIF across multiple even mass and odd mass isotopes."

"The observed pattern of fractionation is characterized by enrichment in all isotopes relative to ^{202}Hg, the most abundant isotope. This pattern is consistent among the different CFL measured, indicating that there is no systematic trend in the magnitude or pattern of fractionation with time. However, Hg clearly becomes incorporated into the glass with time, because we found no trapped Hg in unused lamps, which is consistent with prior research. Further, whole-lamp measurements of used and unused CFL are identical within error to 0‰ (Table 1). This is as expected from mass balance and confirms that CFL are a closed system for Hg [Lattice's comment --- not so]. The largest deviations from our observed pattern of fractionation are the smaller fractionation of ^{196}Hg and the larger fractionation of ^{198}Hg in lamp D. Lamp E, which was used for the same amount of time as lamp D, does not show these offsets. Lamps D and E were aged and processed identically and we cannot provide an explanation for this inconsistency."

"We interpret these results to indicate that Hg isotopes are fractionated between the trapped pool and the bulk reservoir as a result of CFL operation. Accordingly, we expect to see that the isotope composition of Hg in the bulk reservoir is complementary to that in the glass, reflecting mass balance. The trapped Hg is a small fraction of the total Hg in the lamp; less than 1% of the bulk Hg is incorporated into the glass after 3600 h (Table 2). Therefore, the complementary fractionation in the bulk reservoir should be approximately 100 times smaller than of the trapped Hg. Measurements of these two reservoirs are reported in Figure 3 …"



Source: Fig. 1 Mead *et al.* (2013)



Source: Fig. 2 Mead *et al.* (2013)

Mead *et al.*'s inexplicable Hg isotopic data

Admit some data hard to explain with a chemical fractionation process

Quoting directly from the body of their paper:

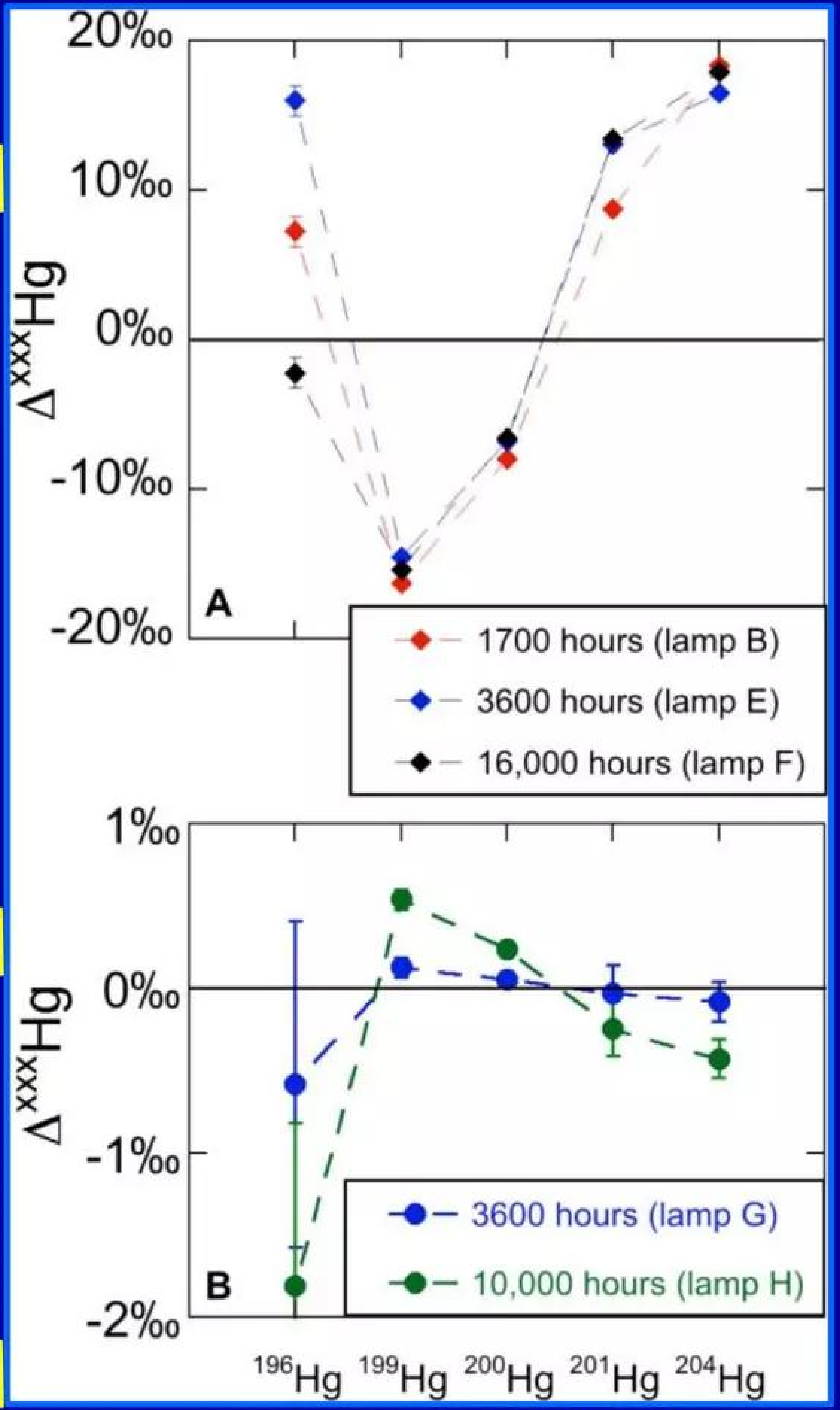
"Previous work describing MIF of Hg has identified two mechanisms of fractionation, the nuclear volume effect and the magnetic isotope effect, both of which produce MIF of ^{199}Hg and ^{201}Hg only. Therefore, these effects alone cannot explain the Hg isotope fractionation within CFL. All isotopes in the CFL Hg are enriched relative to ^{202}Hg, the most abundant Hg isotope, suggesting that the effect is modulated by isotope abundance."

"We suggest that differential excitation among Hg isotopes as a result of self-shielding is a key driver of the observed fractionation in CFL."

"This exercise demonstrates that a self-shielding effect produces the best match to the observed fractionation among known fractionation mechanisms. A poor qualitative match is found when only MDF is invoked (Figure 5A). In contrast, the self-shielding effect fractionation follows the general contour of the measured data (Figure 5B). That fit is improved by invoking self-shielding and MDF together (Figure 5C), which argues that multiple fractionating processes are occurring in the CFL. Incorporating nuclear volume effect or magnetic isotope components similar to published studies did not significantly improve the fit. Much of the remaining misfit is on ^{199}Hg and ^{201}Hg, suggesting that the unusual properties of odd mass isotopes contribute to the fractionation in CFL. This hints at an as yet unknown isotope effect among odd mass Hg isotopes." [Lattice suggests that it could well be LENRs]

"The most similar isotope measurements to those presented here are of Hg in precipitation, published recently by Chen *et al.*, which show Δ^{200}Hg of up to 1.24‰. The findings of Chen *et al.* are intriguing and may be another example of self-shielding driven fractionation. Although the relative values of Δ^{199}Hg, Δ^{200}Hg, and Δ^{201}Hg in that study do not match either our model of self-shielding fractionation (Figure 5B) or our measurements of CFL Hg, it is impossible to rule out self-shielding as the source of fractionation."

"Even including the Chen *et al.* data, FL Hg displays a unique pattern of fractionation …The isotope fractionations reported in this study are unique in the Hg isotope literature …"



Source: Fig. 3 Mead *et al.* (2013)

Mead *et al.*'s inexplicable Hg isotopic data

Admit some data hard to explain with a chemical fractionation process

Discussion

- ✓ **Mead *et al.*'s outstanding experimental results are suggestive and very intriguing; they also admit that some of their data is difficult to explain with any prosaic, non *ad hoc* chemical fractionation mechanisms ("This hints at an as yet unknown isotope effect among odd mass Hg isotopes …").**
- ✓ **In our opinion, data they reported would also be very consistent with expected effects of neutron-catalyzed LENR transmutation processes on Hg operating in parallel with coexisting chemical fractionation processes somewhere inside the CFL system, perhaps in different physical locations**
- ✓ **That said, as it stands today Mead *et al.*'s data on CFLs does not provide enough of the right type of information to be able to decisively conclude that LENRs are in fact occurring in CFLs; neither does it allow us to clearly discriminate between isotopic effects caused by chemical fractionation processes vs. neutron-catalyzed nuclear transmutations; accurate Hg mass balance not measured**
- ✓ **To answer such questions and either falsify or unequivocally confirm the possible role of LENRs in altering Mercury isotopes during operation of CFLs, additional experimentation will be needed**
- ✓ **First, we need to determine whether hydrogen (i.e., protons) in some molecular form(s) are present somewhere inside CFLs and if so, exactly where such Hydrogen is located, in what forms, and in what quantities. Furthermore, we need to know whether Hydrogen, if present, migrates during lamp operation and if so, where does it go. If Hydrogen is not present in any measurable amounts inside CFLs, then there will be no reasonable chance for LENRs to occur and any isotopic shifts should rightly then be attributed entirely to chemical fractionation processes … end of story**

Mead *et al.*'s inexplicable Hg isotopic data

Continued discussed of their fascinating experimental results

Opportunities to pursue additional needed and very interesting experimentation

- ✓ Solid-state NMR spectroscopy can be used to locate H-rich surface sites and track any movement of Hydrogen atoms (i.e., protons in whatever molecular form) within CF lamps from the beginning to the very end of experiments. Interestingly, it seems that Hydrogen may be associated with phosphors lining CFL tubes: manufacturers apply phosphors to tube walls as a liquid suspension mixed with either organic-based solvents or H_2O/Ammonia, after which tubes are baked at elevated temperature to evaporate liquid volatiles and bind mixed-phosphors as micron-scale particles adhering to the glass walls. It is important to know how much Hydrogen survives after the baking and evaporation process and in what molecular form(s) it may exist thereafter

- ✓ Mead *et al.*'s present mass spec technique should be used to look for other elements/isotopes present inside CFLs besides Hg to determine whether: (1) any of these other elements also exhibit anomalous isotope shifts that are difficult to explain with chemical fractionation processes; and (2) there is possible production of other chemical elements that were not known to be present anywhere inside CF lights prior to application of current. If found, and if the presence of such anomalous elements cannot reasonably be explained as the result of some sort of contamination process, then they would be candidates for examples of possible LENR transmutation products

- ✓ Mass spectroscopy technique used by Mead *et al.* is essentially a bulk analytical method which in that sense is akin to neutron activation analysis (NAA). It would be fascinating to examine interior surfaces of CFLs, pre- and post-experiment, with SEM, SEM-EDX, and especially secondary ion mass spectroscopy (SIMS – or best of all, a Cameca nanoSIMS-50) to look for micron-scale crater structures associated with elemental and isotopic heterogeneity and anomalies on small length-scales. Such surface effects are a hallmark signature of LENRs and would be highly indicative of their presence

Mead *et al.*’s inexplicable Hg isotopic data

Continued discussed of their fascinating experimental results

Opportunities to pursue additional needed and very interesting experimentation

- ✓ **Using post-experiment SIMS or SEM-EDX analysis, it would be useful to determine whether nanoparticles of Tungsten sputter off electrodes during light operation and whether they end-up either mixed-in with phosphor coatings or embedded in the glass walls along with Mercury. If so, it would be very interesting to see whether any anomalous isotopic shifts are also found in the Tungsten or even in phosphor materials**

- ✓ **Unambiguous post-experimental detection of anomalous Gold that was clearly not a contaminant and simply not present prior to lamp operation would be a clincher for confirming LENRs in CFL systems. That said, it is still unlikely that CFL neutron fluxes, if present, would be high enough to reach Gold starting with capture on Tungsten. However, intermediate LENR transmutation products such as Osmium or Platinum could potentially be detected *a la* Iwamura *et al.* (2012)**

- ✓ **Indeed, unambiguous post-experimental detection of any anomalous elements that were (1) not reasonably attributable to contamination and (2) were unquestionably absent from the interiors of CFLs prior to application of an electric current would provide very strong evidence that LENRs are occurring therein at non-negligible reaction rates**

If further experimentation demonstrates LENRs can occur in ordinary compact fluorescent lights, it would provide further proof that LENRs are a truly green nuclear technology and that they hold great promise for power generation if device heat outputs can be scaled upwards as Lattice hopes to accomplish in its commercial prototype engineering program for which it is seeking funding.

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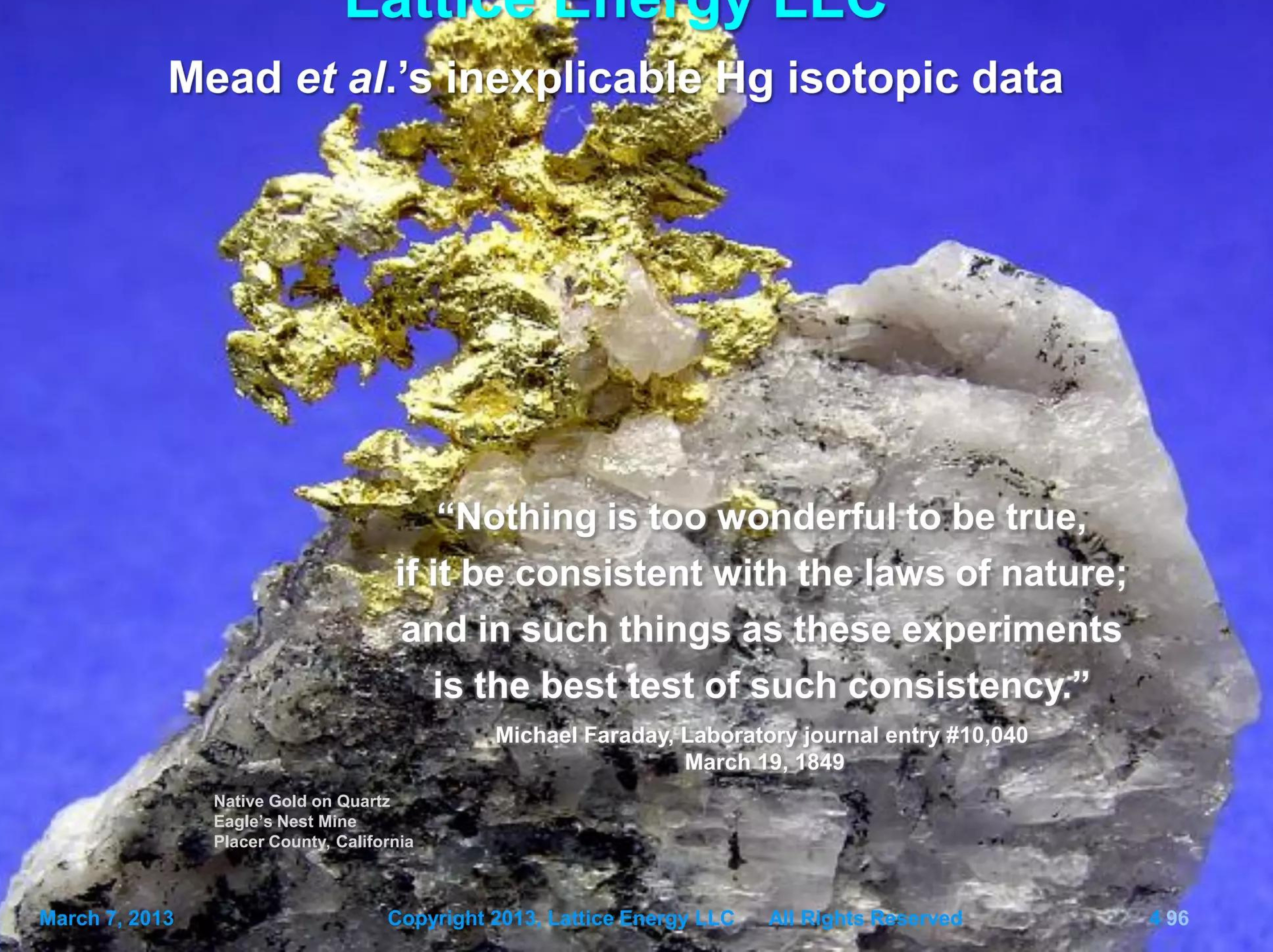
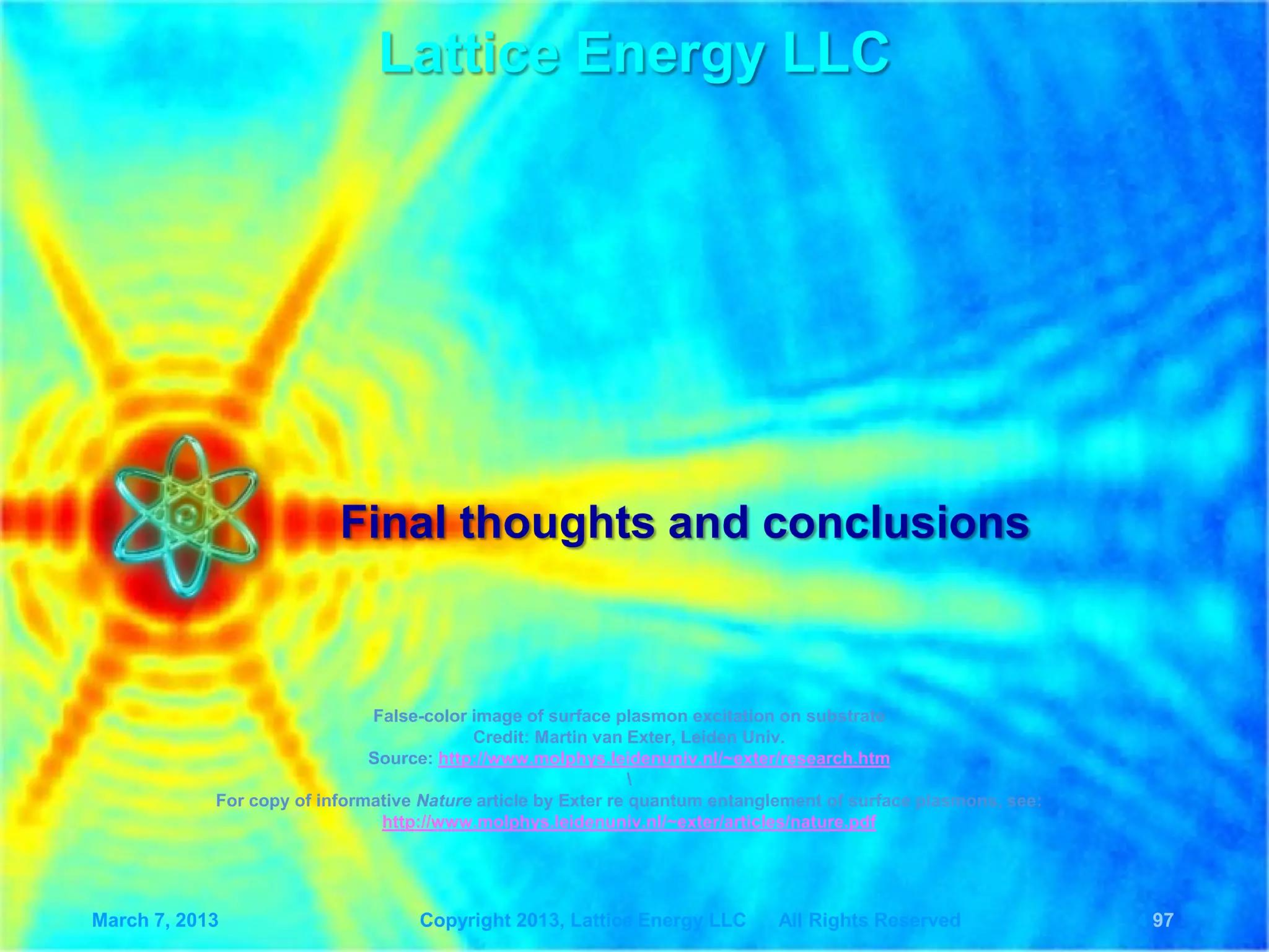
Mead *et al.*’s inexplicable Hg isotopic data



> “Nothing is too wonderful to be true,
> if it be consistent with the laws of nature;
> and in such things as these experiments
> is the best test of such consistency.”

Michael Faraday, Laboratory journal entry #10,040
March 19, 1849

Native Gold on Quartz
Eagle’s Nest Mine
Placer County, California



Final thoughts and conclusions

False-color image of surface plasmon excitation on substrate
Credit: Martin van Exter, Leiden Univ.
Source: http://www.molphys.leidenuniv.nl/~exter/research.htm
\
For copy of informative *Nature* article by Exter re quantum entanglement of surface plasmons, see:
http://www.molphys.leidenuniv.nl/~exter/articles/nature.pdf

Lattice Energy LLC

Final thoughts and conclusions

LENRs occur commonly in Nature and in various manmade processes

Following URLs to Lattice SlideShare presentations provide many such examples; please see:

- ✓ Catalytic converters of cars and trucks during normal vehicular operation: http://www.slideshare.net/lewisglarsen/lattice-energy-llc-len-rs-in-catalytic-convertersjune-25-2010
- ✓ Ordinary atmospheric lightning discharges: http://www.slideshare.net/lewisglarsen/audio-larsenelectroweak-neutron-production-and-capture-in-lightning-dischargesans-san-diego-nov-14-2012
- ✓ Industrial coking ovens during normal operation of pyrolysis processes (Slides #46 - 48): http://www.slideshare.net/lewisglarsen/lattice-energy-llctechnical-overviewpahs-and-lenrsnov-25-2009
- ✓ "Water trees" that can form spontaneously in XLPE electric power cables (Slides #49 - 54): http://www.slideshare.net/lewisglarsen/cfakepathlattice-energy-llc-len-rs-in-liion-battery-firesjuly-16-2010

LENRs do not emit dangerous high-energy neutron or gamma radiation, nor do they produce troublesome quantities of biologically hazardous, long-lived radioactive isotopes. In fact, widely scattered researchers have actually been episodically reporting different types of LENR effects in various major journals for nearly 100 years without really recognizing an array of green nuclear phenomena underfoot that they were clearly observing in their experiments. Lacking expected energetic radiation signatures, LENRs were for the most part hidden in plain sight from mainstream science prior to the advent of the Widom-Larsen theory and vastly greater utilization of modern mass spectroscopy tools by researchers in many different disciplines.

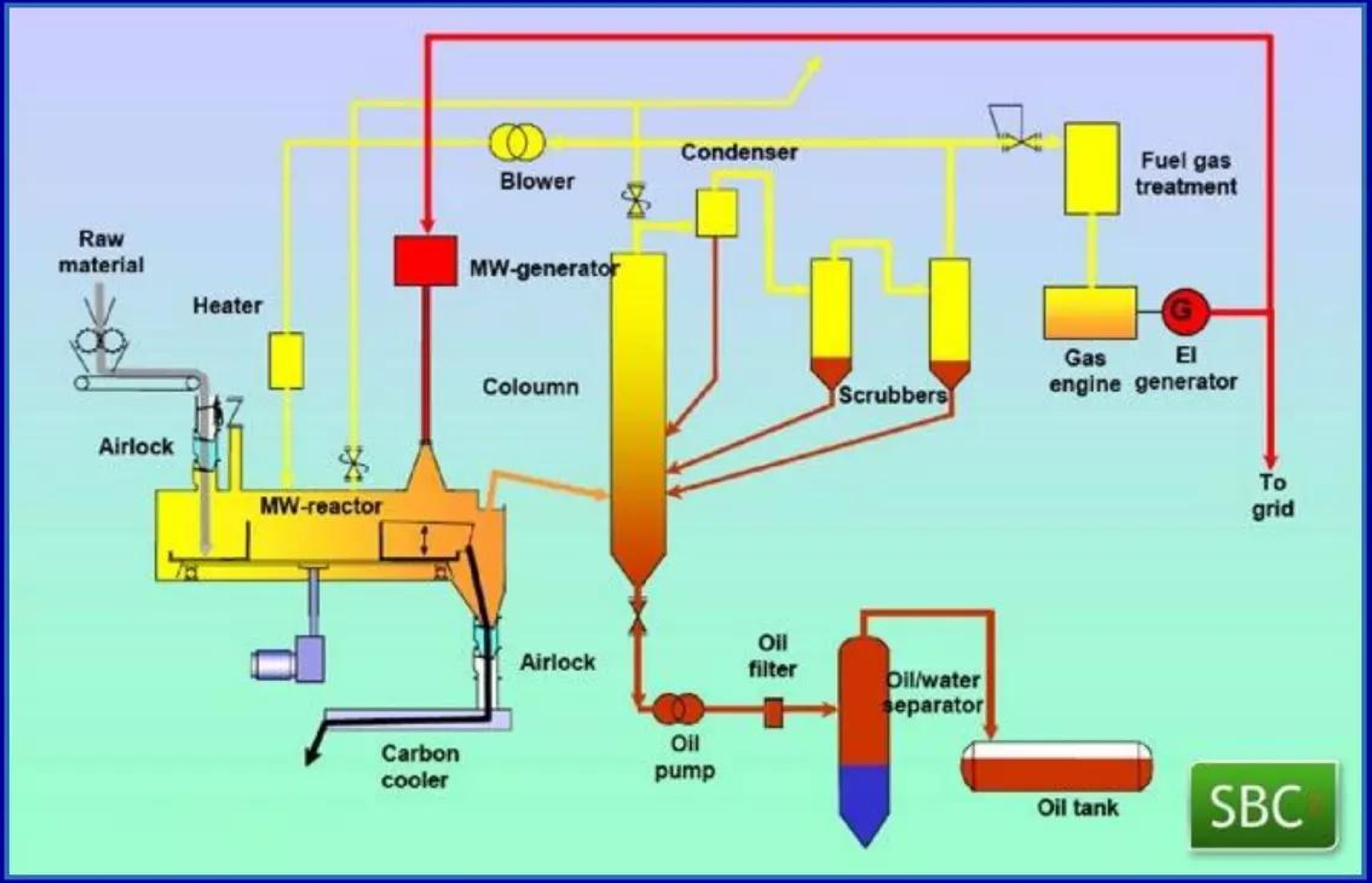
Lattice Energy LLC

Final thoughts and conclusions

LENRs occur commonly in Nature and in various manmade processes

Thus may be hidden in plain sight; can occur in variety of unexpected places

Published data suggests LENRs are occurring in industrial processes like pyrolysis



Credit: Microwave-assisted pyrolysis - Scandinavian Biofuel, Oslo, Norway

"When you have eliminated the impossible, whatever remains, however improbable, must be the truth."

Sherlock Holmes
"The Sign of the Four" (1890)

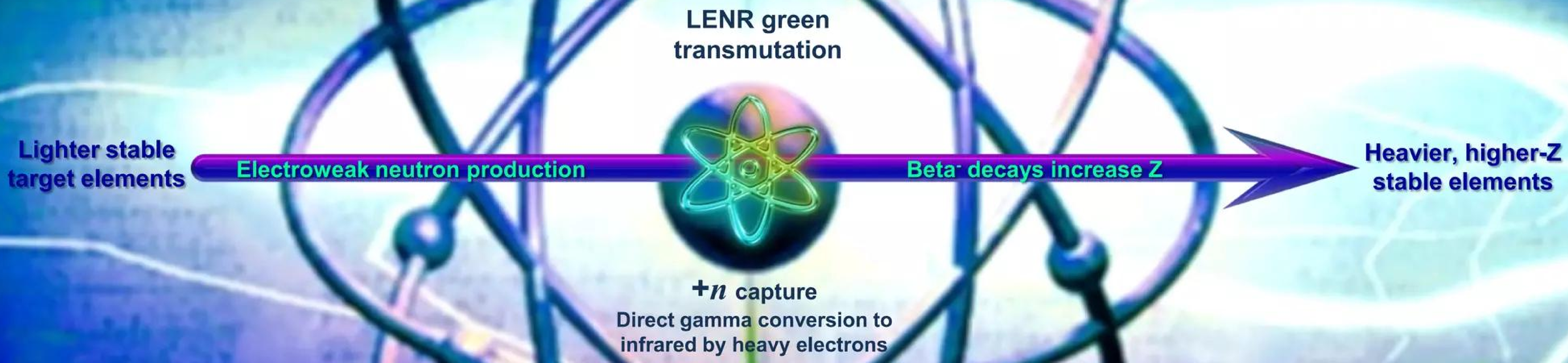
Lattice Energy LLC

Final thoughts and conclusions

- ✓ Herein, we have outlined a theoretical WLT LENR neutron-catalyzed transmutation network that may be subtly altering Mercury isotopes in compact fluorescent lights (CFL) during normal operation in homes over lifetimes amounting to as much as 10,000 hours
- ✓ Anomalous shifts in abundances of stable Mercury isotopes that are consistent with the operation of such a network in CFLs have recently been reported by Mead *et al*. (2013)
- ✓ Have identified opportunities for further experimental measurements on CF lights such as using SIMS to examine nm- to micron-scale regions on interior surfaces of fluorescent lamps to look for evidence of anomalous local isotopic shifts in other elements in addition to Mercury as well as to detect possible production of other chemical elements that were not known to be present anywhere inside lights prior to application of current
- ✓ Also need to use solid-state NMR spectroscopy to locate H-rich surface sites and track any movement of Hydrogen atoms (i.e., protons in whatever molecular form) within CF lamps from the beginning to the very end of experiments; LENRs can only occur in locations where protons are locally available to react with, for example, surface plasmon electrons on metals and/or π electrons found on hydrogenated molecular aromatic rings
- ✓ Note that disequilibrium input energy is required to fully energize LENR-active sites on materials found on interior surfaces of CFLs (this additional input of energy is absolutely necessary to produce ultra low momentum neutrons via $e + p$ reaction) can come from just one source or any combination of electron currents and/or UV/IR/visible photons

Lattice Energy LLC

Final thoughts and conclusions



LENR green transmutation

Lighter stable target elements

Electroweak neutron production

Beta$^-$ decays increase Z

Heavier, higher-Z stable elements

$+n$ capture

Direct gamma conversion to infrared by heavy electrons

> **"An era can be said to end when its basic illusions are exhausted."**

Arthur Miller, American playwright and essayist
"When it came apart," *New York Magazine*
Dec. 30, 1974 - Jan. 6, 1975

Medieval alchemist's lament?

"Chasing the Rainbow"
Artist: America (Beckley & Bunnell)
Album: "Here and Now" rlsd. January 16, 2007
Publisher: Sony-BMG Records

"Sat here thinking about my heart,
All of the places it came apart.
There's just one thing that I need to know,
Why am I always chasing the rainbow?

Get it get it get it get it get it get it get it uh huh.
I ran through the meadow looking for a dream,
Truth is never like what it seems.
I guess there's always so far to go.
Why am I always chasing the rainbow?

Get it get it … chasing the rainbow.
Get it get it get it … uh huh.

Where is the light? Where is the love?
Where are the dreams that I once had?
Frittered away.
Gone in the time it takes to get from there to here!

Get it get it get it … uh huh.
Get it get it get it … chasing the rainbow.
Why am I always chasing the rainbow?

I'd draw you a picture 'cause it just might help,
To point out the place where we went so wrong.
The only color I'd use is blue.
Why am I always chasing the rainbow?

Why am I always chasing the rainbow?
Get it get it … chasing the rainbow.
Get it get it get it uh huh …………"

Studio video of "Chasing the Rainbow" [3 min 21 sec]

http://www.youtube.com/watch?v=JCruo1N5FH8