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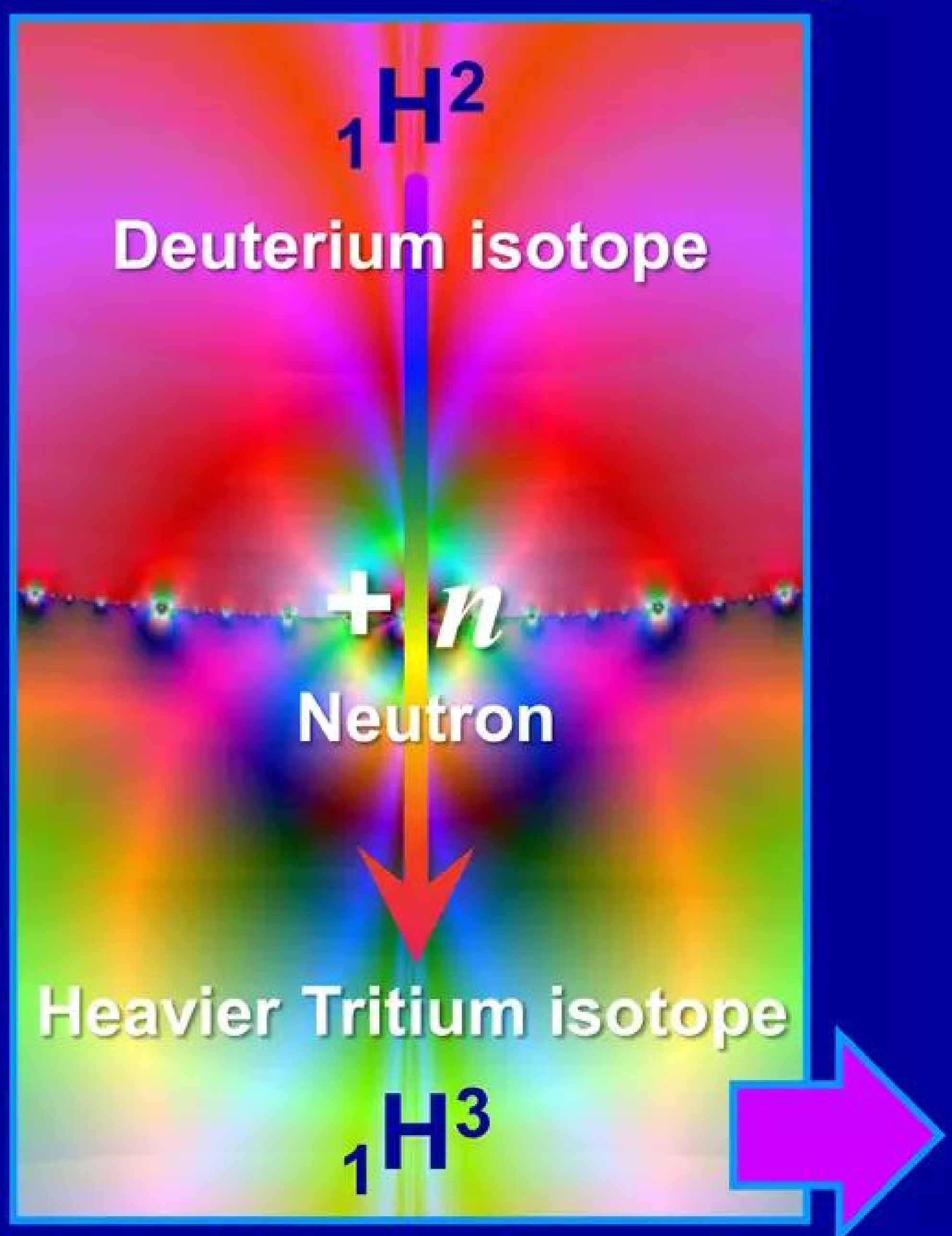
Russian experiments further confirm Widom-Larsen

New results are fully explained and predicted by our theory

Used laser irradiation of metallic targets in D_2O to produce detectable Tritium

Production of Tritium from D_2O



Transmutation via neutron capture

Technical Discussion

Lewis Larsen

President and CEO
Lattice Energy LLC
June 13, 2013

"For the truth of the conclusions of physical science, observation is the supreme Court of Appeal."

Sir Arthur Eddington
"*The Philosophy of Physical Science*" pp. 9 (1939)

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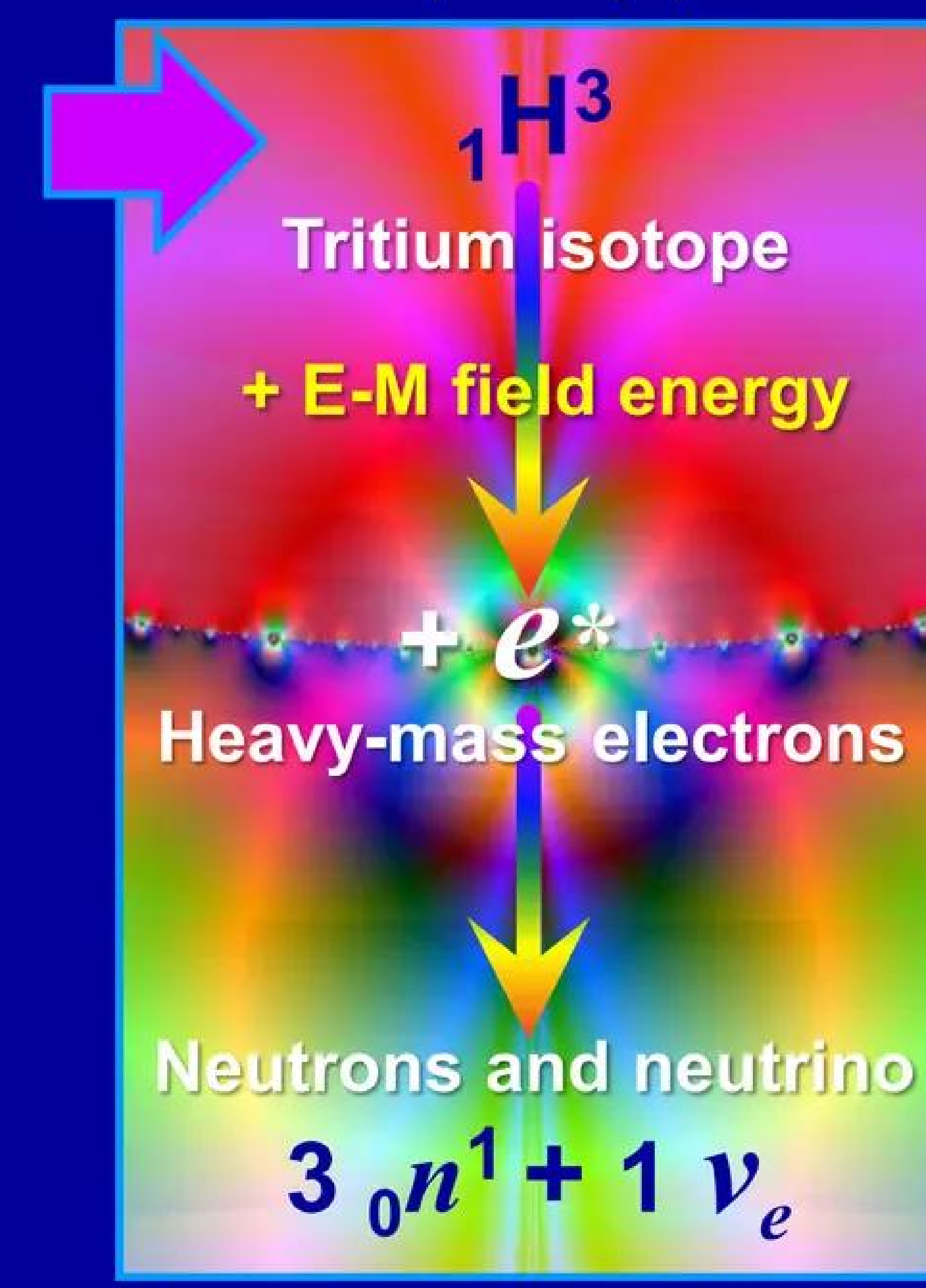
lewisglarsen@gmail.com
http://www.slideshare.net/lewisglarsen

Destruction ("decay") of Tritium



Conversion of Tritium into neutrons

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Overview of their experimental work and theory

Barmina et al. arXiv:1306.0830v1 explained by W-L theory

- ✓ In series of different experiments with laser irradiation (sometimes combined with electrolysis) of hydride-forming metallic targets immersed in D_2O, Barmina *et al.* claim to have observed both production and so-called "*accelerated decay*" of Tritium
- ✓ If correct, their claimed detection of significant amounts of radioactive Tritium production is an extremely interesting experimental result because over the past 24 years, out of the *hundreds of thousands* of LENR experiments conducted, literally only a handful have ever claimed to observe Tritium as a measurable nuclear product
- ✓ In separate very recent publications (2012, 2013), Barmina *et al.* claim to have developed a theory which can explain all their experimental data; their theoretical approach includes 'new nuclear physics' and exotic concepts such as a so-called "*in-shake-up*" nuclear state that enables production of new bound di-/tri-neutron particles
- ✓ Presuming that their experimental data are shown to have been correctly measured and results are successfully repeated by other independent researchers, their reported data provides further confirmation of Widom-Larsen theory of LENRs in a type of laser-based LENR experimental system pioneered by Letts & Cravens (USA) *ca.* 2002 - 2003

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Summary comments

Widom-Larsen physics best explains Barmina et al.'s data

- ✓ Widom-Larsen theory of LENRs fully explains Barmina *et al.'s* experimental data as result of laser- and/or electrolysis-triggered, collective electroweak neutron production and captures on Hydrogen isotopes and target materials; WLT predicts that using lasers to provide input energy (see comment on pp. 4 in 2006 *EPJC* paper) can enhance rates of neutron production on surfaces of H-loaded hydrides
- ✓ Barmina *et al.*'s laser triggering experiments represent valuable extension of earlier laser work in LENR systems that occurred in the US and Italy a decade or so ago
- ✓ While their new theory may well be flawed and offer no useful advantages over Widom-Larsen, their experiments are worth repeating by independent third parties
- ✓ In arXiv:1306.0830v1, Barmina *et al*. did not cite: previously published, peer-reviewed *EPJC* LENR theory paper by Widom & Larsen (2006); or *Pramana* theory paper by Srivastava, Widom & Larsen (2010); or experimental work of either Violante *et al*. (2003, 2004) or Letts & Cravens (2003). All of these prior publications are directly relevant to and in fact consistent with their reported results and data

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Relevant references

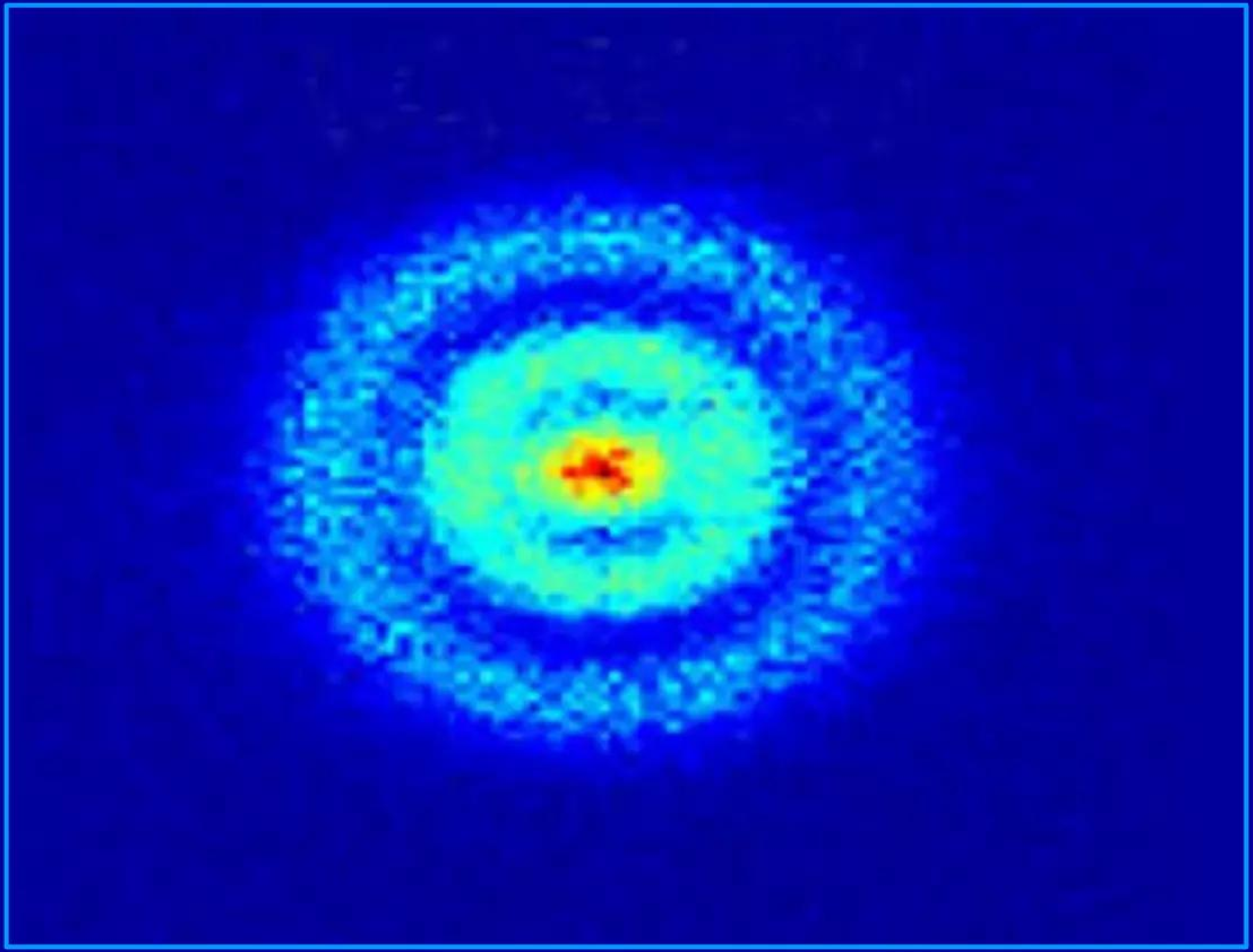

Image credit: first-ever direct image obtained of the electronic orbital structure of the Hydrogen atom; A. Stodolna *et al.*, "*Hydrogen Atoms under Magnification: Direct Observation of the Nodal Structure of Stark States,*" *Phys. Rev. Lett.* 110 pp. 213001 (2013)

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Relevant references

"Laser-induced synthesis and decay of Tritium under exposure of solid targets in heavy water"

E. Barmina, P. Kuzmin, S. Timashev, and G. Shafeev

arXiv:1306.0830v1 June 3, 2013

http://arxiv.org/ftp/arxiv/papers/1306/1306.0830.pdf

Abstract: "The processes of laser-assisted synthesis of Tritium nuclei and their laser-induced decay in cold plasma in the vicinity of solid targets (Au, Ti, Se, etc.) immersed into heavy water are experimentally realized at peak laser intensity of 10^{10} - 10^{13} W/cm^2. Initial stages of Tritium synthesis and their laser-induced beta-decay are interpreted on the basis of non-elastic interaction of plasma electrons having kinetic energy of 5-10 eV with nuclei of Deuterium and Tritium, respectively."

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Relevant references

"Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces"
A. Widom and L. Larsen [first peer-reviewed paper published on Widom-Larsen theory; preprint on arXiv May 2005]
***European Physical Journal C - Particles and Fields (EPJC)* 46 pp. 107 - 112 (2006)**
http://www.slideshare.net/lewisglarsen/widom-and-larsen-ulm-neutron-catalyzed-lenrs-on-metallic-hydride-surfacesepjc-march-2006 [as-published author's copy of paper]

Abstract: "Ultra low momentum neutron catalyzed nuclear reactions in metallic hydride system surfaces are discussed. Weak interaction catalysis initially occurs when neutrons (along with neutrinos) are produced from the protons that capture 'heavy' electrons. Surface electron masses are shifted upwards by localized condensed matter electromagnetic fields. Condensed matter quantum electrodynamic processes may also shift the densities of final states, allowing an appreciable production of extremely low momentum neutrons, which are thereby efficiently absorbed by nearby nuclei. No Coulomb barriers exist for the weak interaction neutron production or other resulting catalytic processes."

"A primer for electro-weak induced low energy nuclear reactions"
Y. Srivastava, A. Widom, and L. Larsen [review paper; covers all theoretical aspects of Widom-Larsen theory to date]
***Pramana - Journal of Physics* 75 pp. 617 - 637 (2010)**
http://www.ias.ac.in/pramana/v75/p617/fulltext.pdf

Abstract: "Under special circumstances, electromagnetic and weak interactions can induce low-energy nuclear reactions to occur with observable rates for a variety of processes. A common element in all these applications is that the electromagnetic energy stored in many relatively slow-moving electrons can (under appropriate circumstances) be collectively transferred into fewer, much faster electrons with energies sufficient for the latter to combine with protons (or deuterons, if present) to produce neutrons via weak interactions. The produced neutrons can then initiate low-energy nuclear reactions through further nuclear transmutations. The aim of this paper is to extend and enlarge upon various examples analyzed previously, present order of magnitude estimates for each and to illuminate a common unifying theme amongst all of them."

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Relevant references

"Laser stimulation Of Deuterated Palladium: past and present"
D. Letts and D. Cravens [as-provided to attendees; may differ from final version published in *Proceedings*]
Proceedings of the 10th International Conference on Cold Fusion (ICCF-10), Cambridge, MA. Aug. 24 - 29, 2003
World Scientific; Singapore ISBN-13:978-9812565648 (2006)
http://lenr-canr.org/acrobat/LettsDlaserstimu.pdf

Abstract: "A method is disclosed to fabricate a Palladium cathode that can be electrolyzed in heavy water and stimulated with a laser at a predetermined wavelength to produce apparent excess power; the fabrication method involves cold working, polishing, etching and annealing the Palladium prior to electrolytic loading with Deuterium. Loading is accomplished with the cathode sitting in a magnetic field of 350 Gauss. After loading the cathode with Deuterium, Gold is co-deposited electrolytically on the cathode. When a coating of Gold is visible on the cathode, co-deposition is halted and the cathode is stimulated with a low-power laser with a maximum power of 30 milliwatts. The thermal response of the cathode is typically 500 mW with maximum output observed of approximately 1 watt. The effect is repeatable when protocols are followed and has been demonstrated in several laboratories."

"Index to key documents and concepts"
L. Larsen [54 MS-PowerPoint slides in version #10 updated through June 1, 2013]
Lattice-published document on SlideShare.net (2013) [document is periodically updated to add new entries]
http://www.slideshare.net/lewisglarsen/lattice-energy-llc-index-to-documents-re-widomlarsen-theory-of-lenrsmay-28-2013

Purpose and contents: this just-updated, comprehensive Index contains master list of documents, summaries, and hyperlinks to online resources; it was specifically created to help interested parties efficiently navigate through W-L's theoretical concepts and relevant experimental data found in a large collection of various documents and do so at a technical level with which they can feel comfortable

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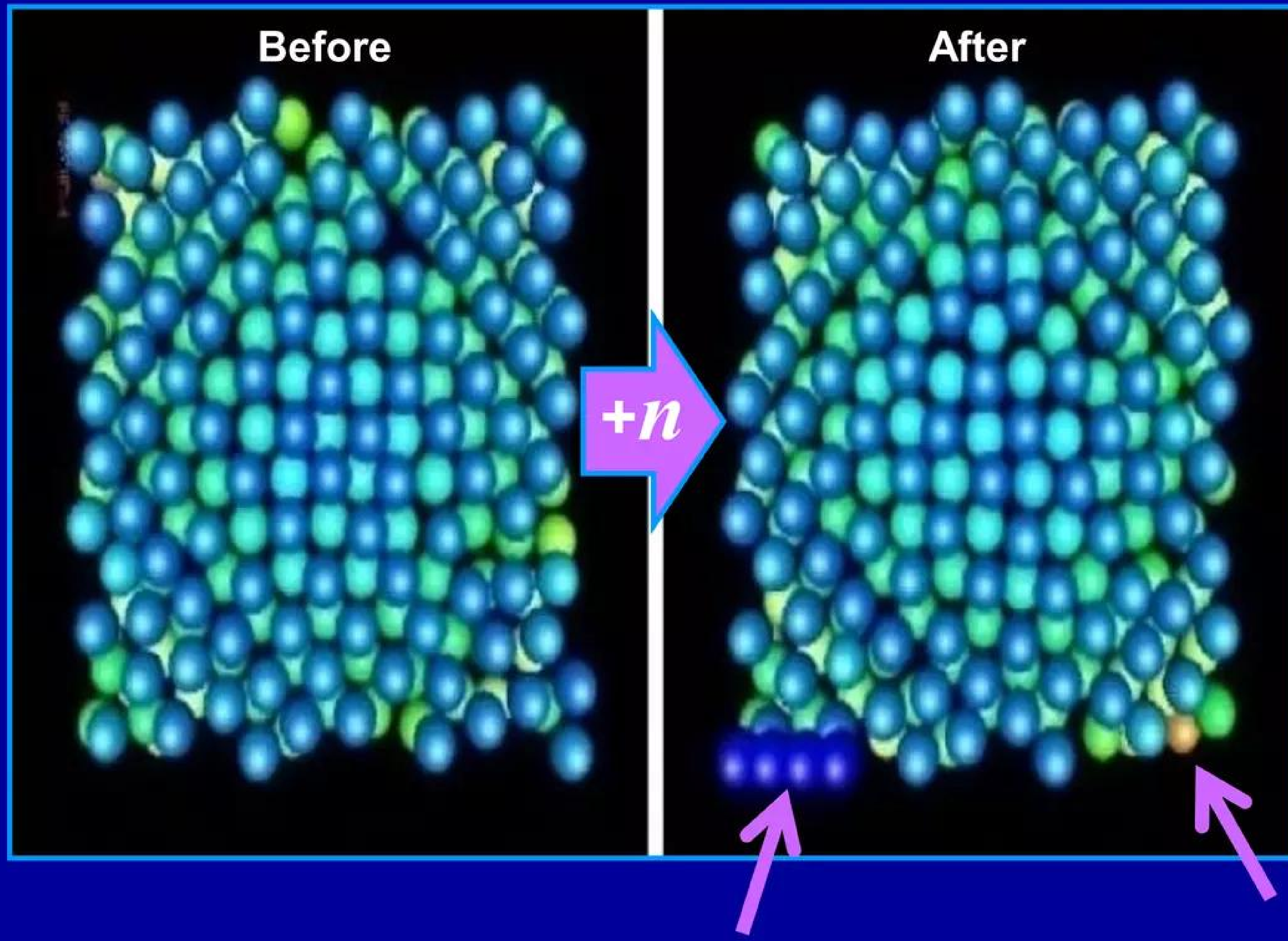
Widom-Larsen Theory of LENRs

Atoms transmuted with uncharged neutrons; no Coulomb barrier



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Widom-Larsen theory can explain LENRS

W-L theory was developed after careful evaluation of a very large body of published experimental data; unlike published work by competing theorists, it successfully explains three key features that uniquely differentiate LENRs from better known few-body nuclear processes such as fission and fusion:

- ✓ Overcoming the Coulomb energy barrier without having star-like temperatures: weak interaction-based W-L posits that neutrons and neutrinos are created from protons and heavy-mass electrons via many-body collective processes that also create nuclear-strength local electric fields on surfaces of H-loaded condensed matter metallic hydrides. Unlike few body charged-particle D-D fusion, no Coulomb barrier to neutron capture by nuclei since neutrons are uncharged; collective triggering of LENRs does NOT need high temperatures
- ✓ Absence of large emissions of dangerous high-energy neutrons: ultra low momentum (ULM) neutrons of W-L have enormously low kinetic energies and huge absorption cross sections; are therefore very efficiently captured by any nearby nuclei. Thus, ULMNs are very difficult to detect directly; however, ULM neutrons finally observed indirectly by Cirillo *et al.* (2012)
- ✓ Absence of large, dangerous emissions of MeV-energy gamma radiation: in condensed matter LENR systems, Q-M entangled heavy-mass surface plasmon (SP) electrons have a unique ability to absorb gamma rays and convert them directly into lower-energy infrared photons. In LENR systems, deadly gammas produced during neutron captures and/or beta decays are absorbed and converted into heat internally rather than being emitted externally

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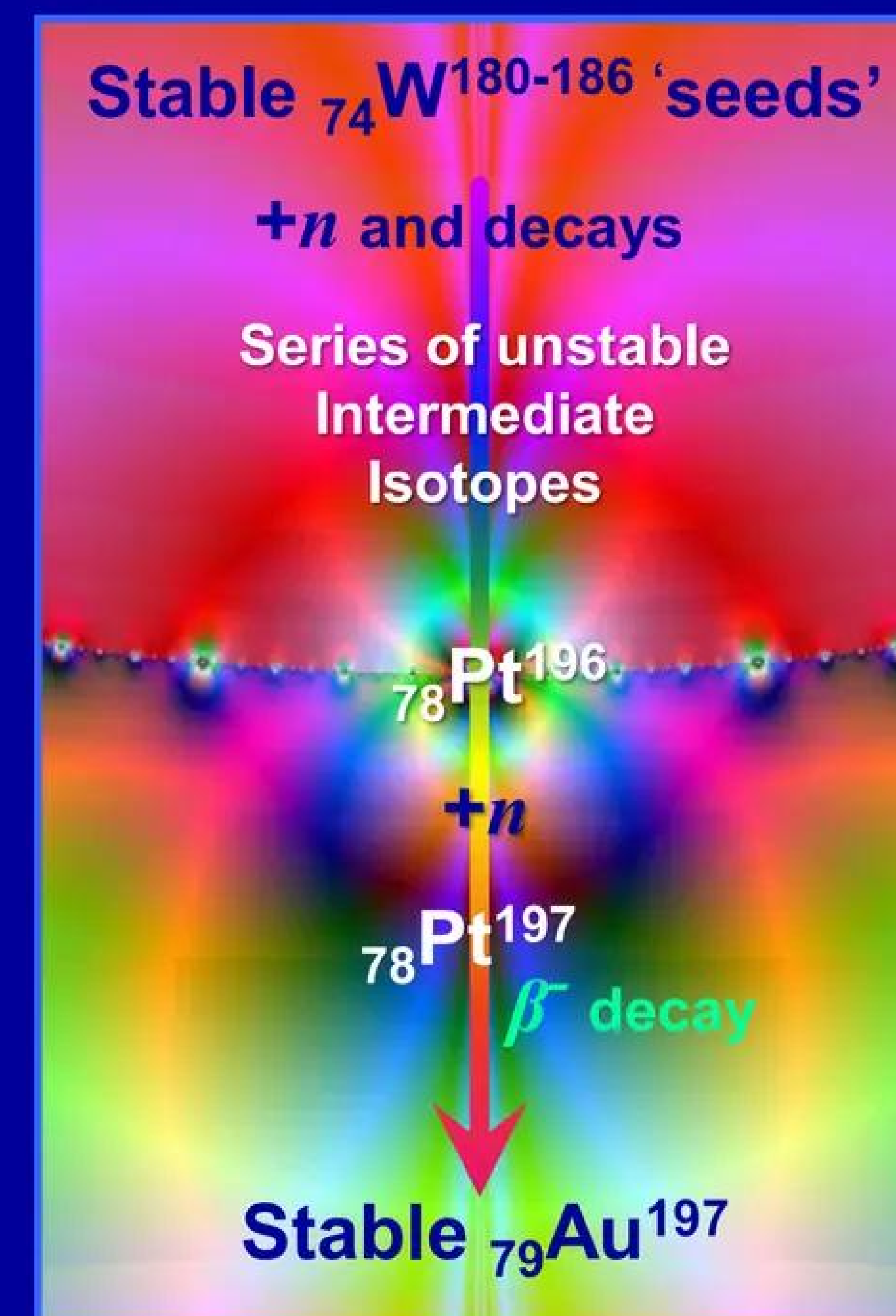
LENRs can occur under very moderate conditions

Don’t need star-like temperatures and huge pressures to trigger them

- ✓ **Prior to Widom-Larsen theory, astrophysicists believed that “neutronization” (direct e^- + p^+ reaction) could only readily occur deep in cores of dying stars during supernova detonations**
- ✓ **<u>No</u> “new physics” in *any* of W-L: all we did was integrate many-body collective effects with modern electroweak theory under the ‘umbrella’ of the Standard Model; vast amount of published experimental data consistent with Widom-Larsen**
- ✓ **Absent help from condensed matter many-body collective effects + quantum entanglement (i.e., physics *aikido*), <u>none</u> of W-L’s electroweak processes could ever occur at high rates under moderate temperature/pressure in chemical cells**

Gold (Au) production from Tungsten (W) using electric arcs in hot transformer oil



First discovered by Prof. Hantaro Nagaoka (Japan) and then reported in *Nature* (1924)

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Widom-Larsen theory explains LENRs

Many-body collective effects enable non-stellar nuclear processes

Reactants + E-M input energy → neutrons:

$Energy_{E\text{-}field} \rightarrow e^{-*} + p^{+} \rightarrow n + \nu_e$ [chemical cells]

$Energy_{B\text{-}field} \rightarrow e^{-} + p^{+} \rightarrow lepton + X$ [solar flares]

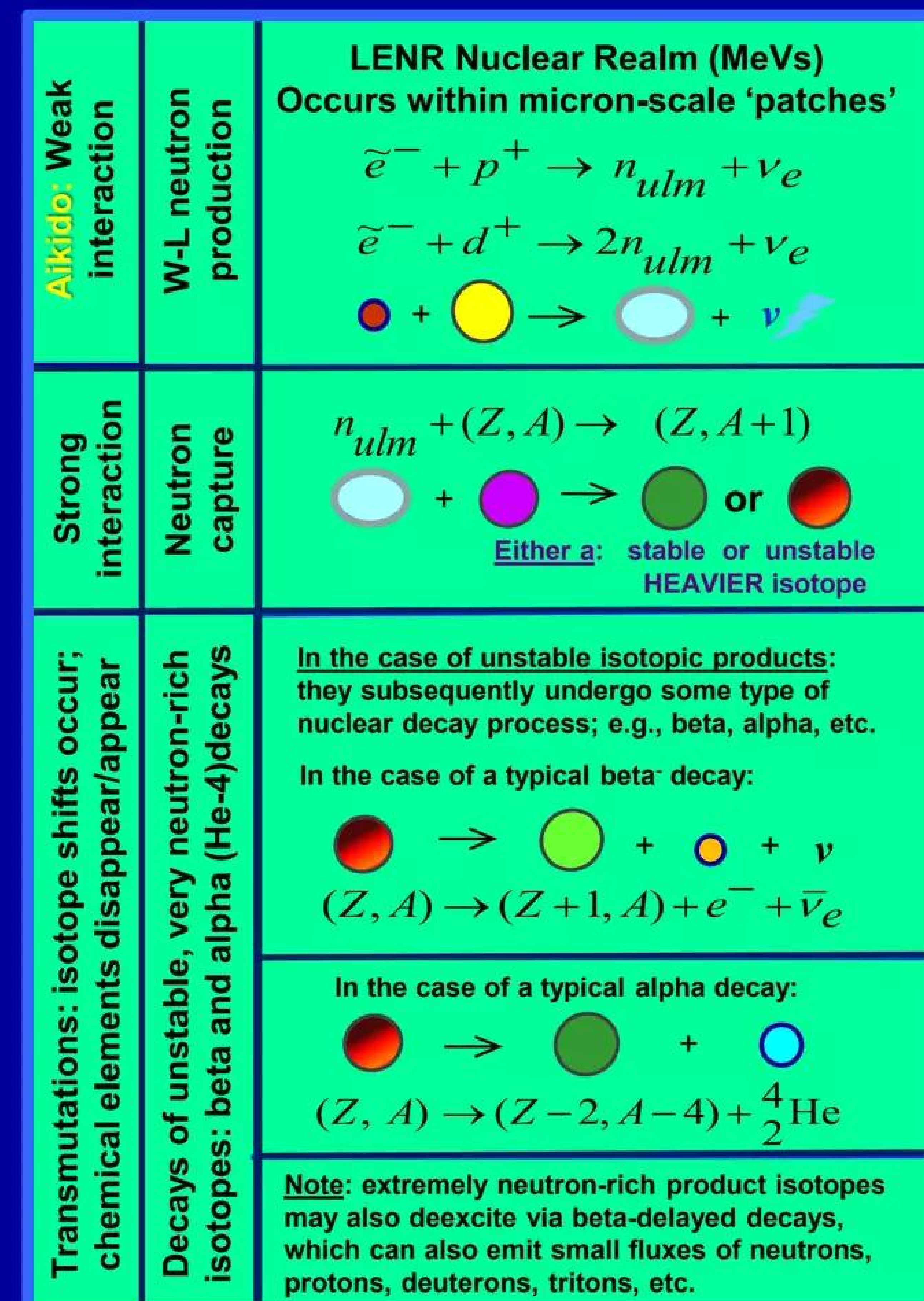
Collective electroweak production of neutrons on μ-scales in condensed matter and large-length-scale magnetic regimes in arcs, lightning, and flux tubes

Afterwards neutrons capture on 'targets':

$n + (Z, A) \rightarrow (Z, A+1)$ [neutron capture]

$(Z, A+1) \rightarrow (Z+1, A+1) + e_{\beta}^{-} + \nu_e$ [beta$^-$ decay]

Commonly have β^- decays of neutron-rich isotopic products; also α-particle decays, among others



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Electroweak interactions: key ideas in W-L theory

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

Steps 1. through 3. are very fast; can complete in 2 to 300 nanoseconds

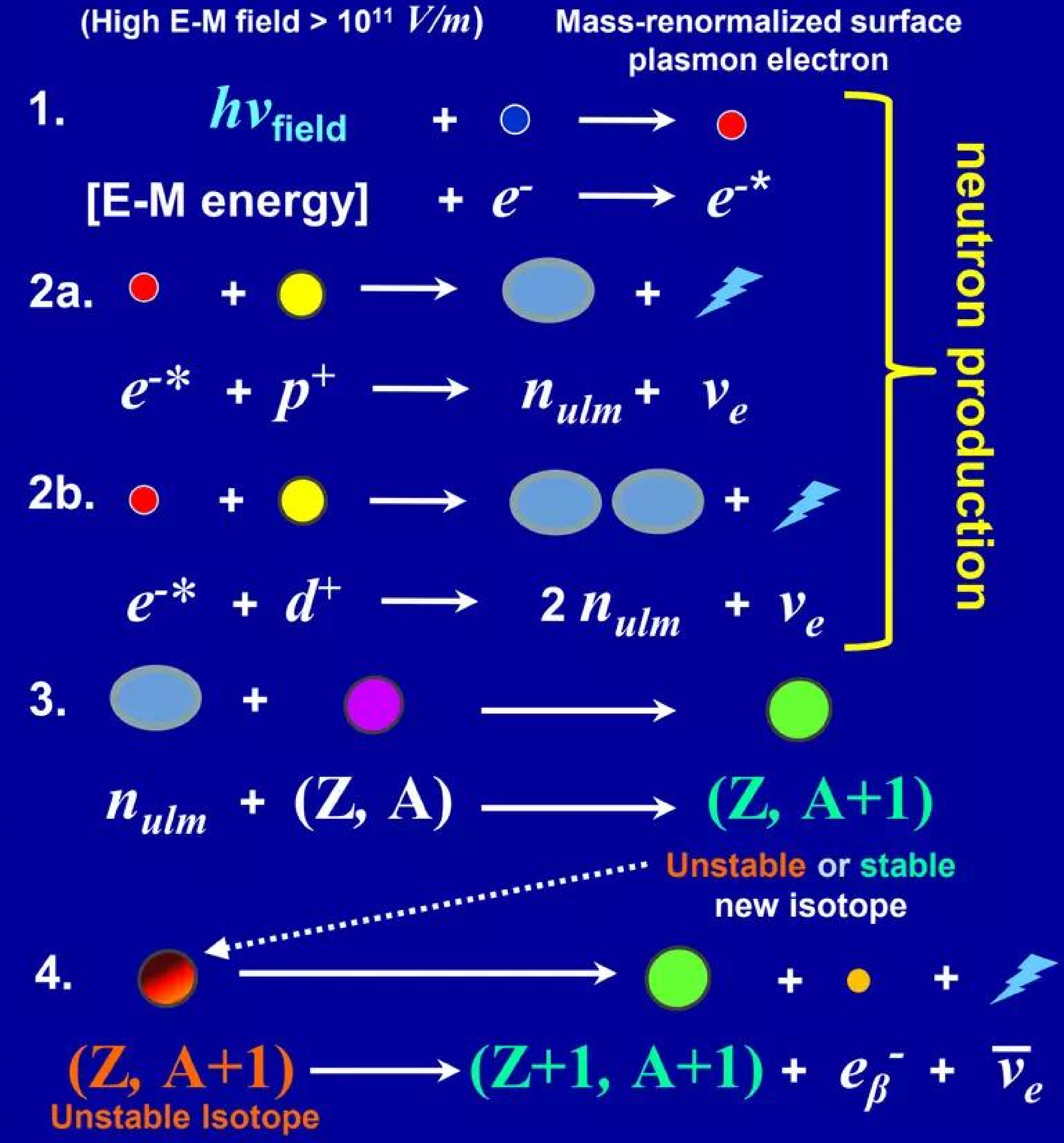
1. Electromagnetic (E-M) radiation impinging on the surface of a metallic hydride can increase the effective mass of surface plasmon (SP) electrons ($e^- \rightarrow e^{-*}$)

2. Heavy-mass surface plasmon electrons can react directly with (a) surface protons (p^+) or (b) deuterons (d^+) to produce 1 ultra low momentum (ULM) neutron n_{ulm} or 2 n_{ulm}, respectively) and an electron neutrino (ν_e) photon

3. Ultra low momentum neutrons (n_{ulm}) are captured by nearby atomic nuclei (Z, A) representing some element with nuclear charge (Z) and atomic mass (A). ULM neutron absorption produces a heavier-mass isotope ($Z, A+1$) via transmutation. The new isotope ($Z, A+1$) may itself be stable or unstable (which will eventually decay)

4. Many unstable isotopes will β^- decay, producing a transmuted element with increased nuclear charge (Z+1) and ~same mass (A+1) as the 'parent' nucleus, as well as a β^- particle (e_β^-) and an antineutrino ν_e photon ($\overline{\nu}_e$)

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



Neutron production and weak interaction β^- decays (shown just above) are both electroweak processes

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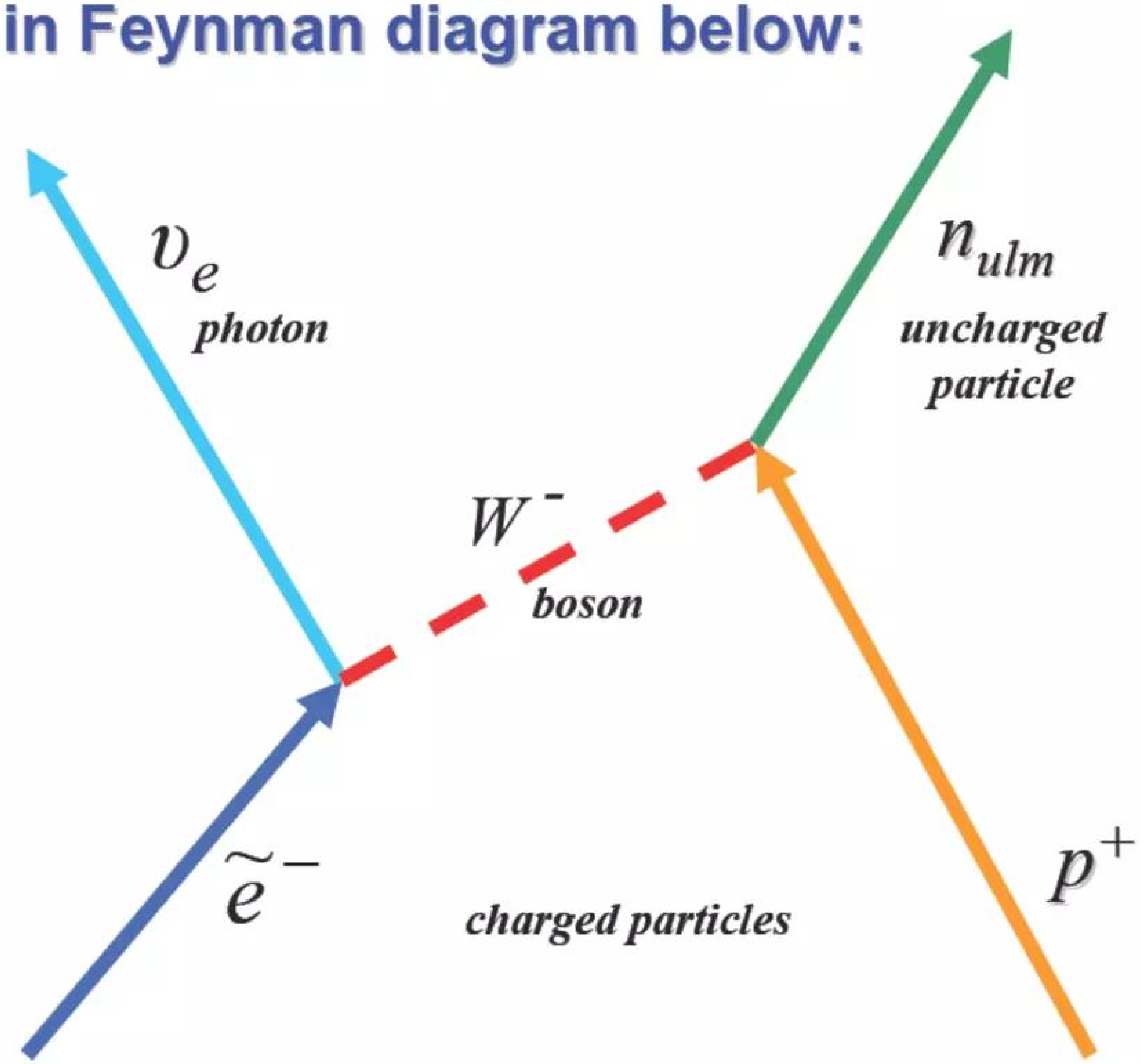
Process written down as a 2-body *e* + *p* reaction

What actually <u>happens</u> in Nature is a collective many-body process

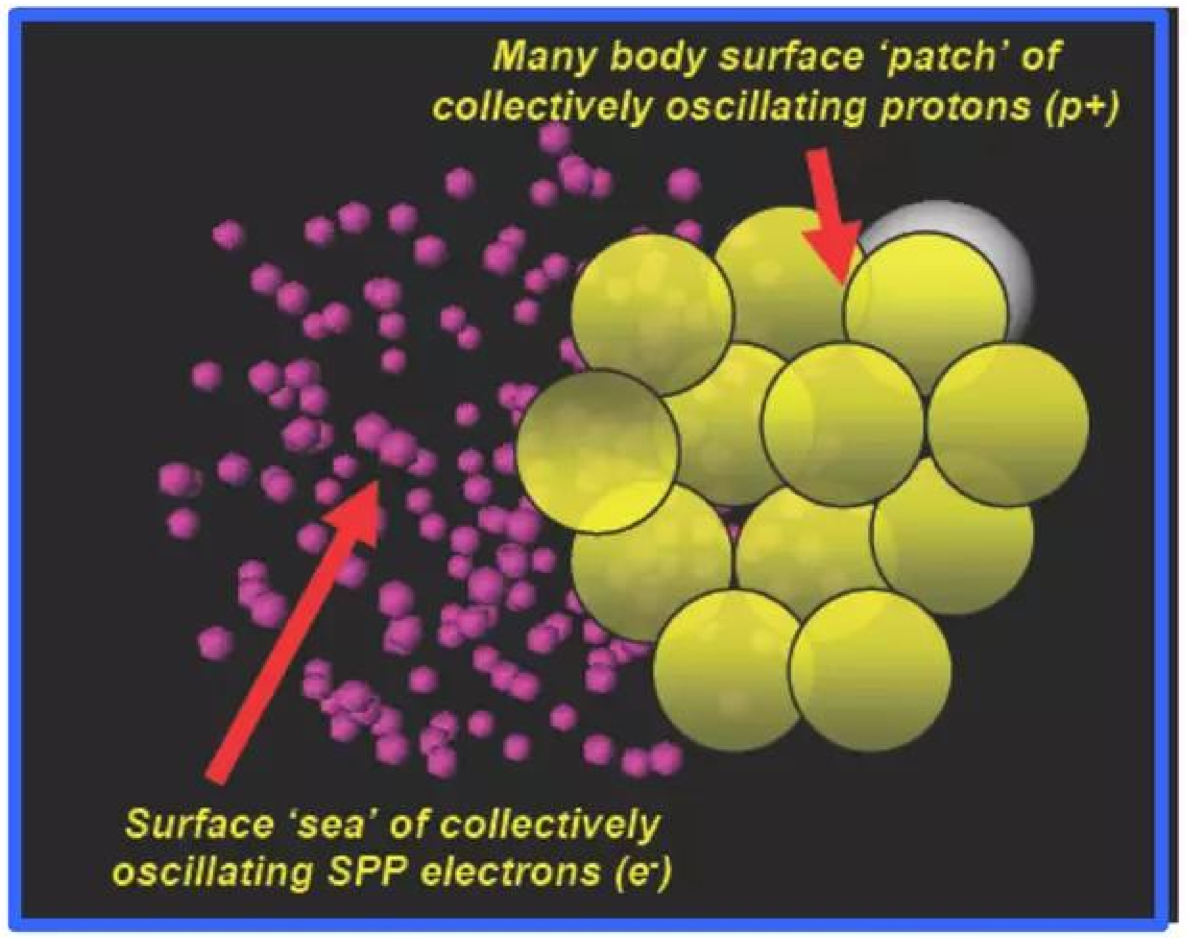
Simple two-body collision shown in Feynman diagram below:



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

What really <u>happens</u> here is many-body

Now add collective rearrangements from condensed matter effects. It is not just a two body collision !!!



Above is what really occurs on metallic hydride surfaces

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Widom-Larsen spans microcosm to macrocosm

Short-Range Collective Electric Field Effects Dominate

Longer-Range Collective Magnetic Field Effects Begin to Dominate

Long-Range Collective Magnetic Field Effects Dominate

Collective nuclear 'aikido'

Many-body collective magnetic 'taekwondo'

Regime of mostly *very* low energy neutron reactions: LENRs dominate

W-L: $e^* + p^+ \rightarrow$ 1 neutron + neutrino **or** $e^* + d^+ \rightarrow$ 2 neutrons + neutrino

Neutron production and capture release energy, create transmutation products

Low to medium electric and/or ion currents

- Microorganisms - biological transmutations by some types of earthly bacteria and fungi
- Pressure gradients across membranes - e.g., Iwamura, Arata (Japan); Li (China); gas phase
- Current-driven P&F-type chemical cells - liquid phase; glow discharge cells - gas phase
- Laser-triggered chemical cells - e.g., Letts & Cravens; Violante, Barmina; liquid/gas phase

High currents: electrons and/or ions

- RF-triggered dusty plasmas - e.g., Mills (USA); Univ. of Florida in 1960s (USA); gas phase
- Current-driven dusty plasmas; gaseous phase only (literature mainly within last 15 years)
- Vacuum diodes - e.g., Proton-21 (Ukraine); Sandia N.L. (USA) in mid-1970s; gas phase only
- Exploding wires - e.g., Wendt & Irion 1922 (USA); Z-pinch at Sandia N.L. (USA); gas phase
- Magnetic flux compression generators - e.g., Los Alamos N.L. (USA); institutes in Russia
- Lightning (terrestrial, planetary, nebular), especially in dusty environments - e.g., Dwyer
- ULMN-catalyzed subcritical fission reactors (<<< nuclear waste) - reprocess stored wastes

Higher fluxes of neutrons

Scales-up to very large length scales — Wide range of magnetic field strengths

W-L mixed regime: high energy particle reactions and/or LENRs on dust

Magnetic effects dominate large length-scale plasmas: $e^- + p^+ \rightarrow$ lepton + X

Mega-scale currents

- Stars: additional nuclear reactions occur in photospheres, flares, and further out in coronas
- Dusty, hydrogen-rich nebular plasma clouds exposed to stellar photon and particle radiation
- Magnetars/active galactic nuclei: W-L mechanism can in theory create UHE TeV cosmic rays

>>>> fluxes

~0 eV Ultra low momentum neutrons .... MeV neutrons ...GeV neutrons ....TeVs

Increasing neutron and charged particle energies

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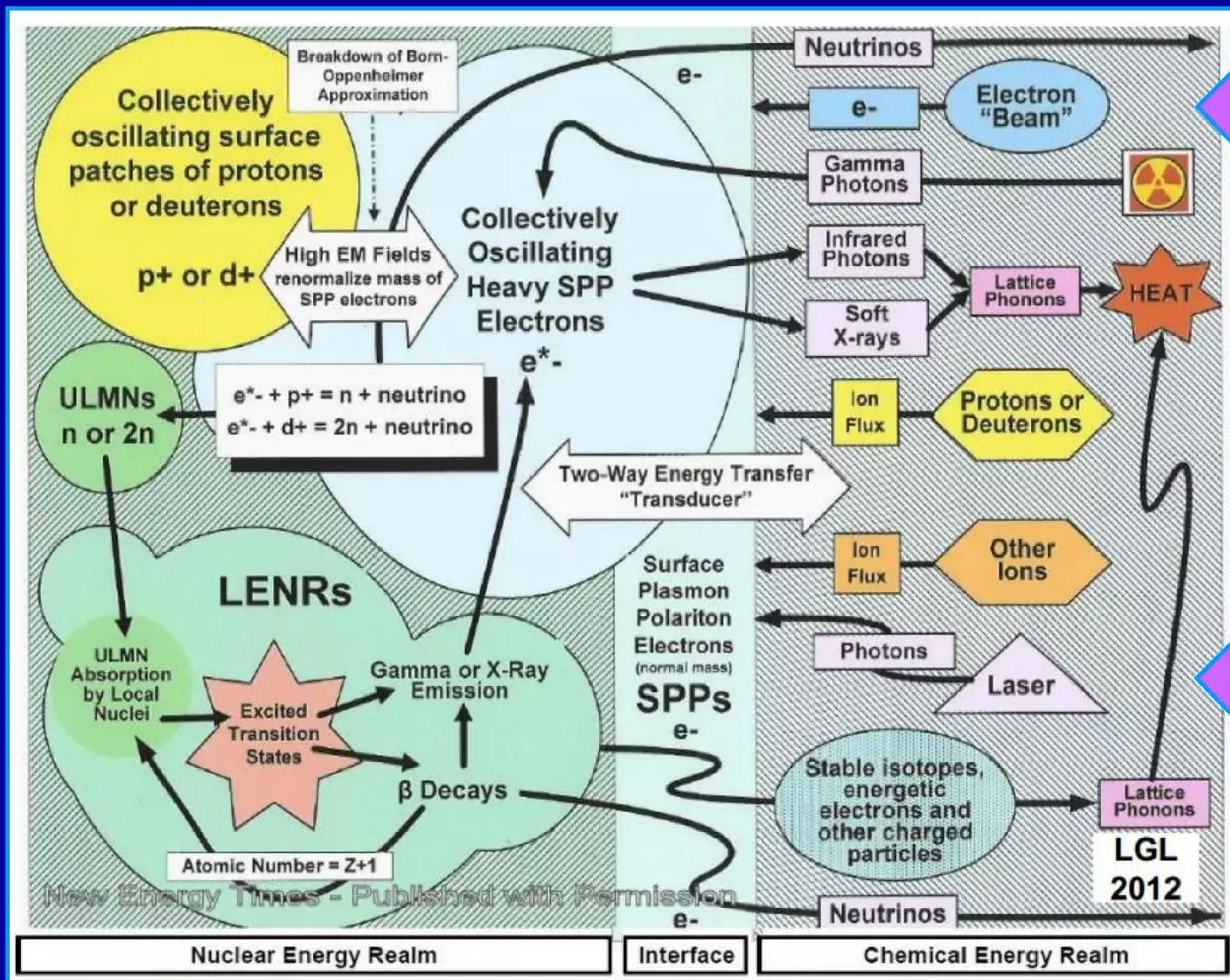
Overview: W-L in condensed matter systems

Chemical and nuclear realms interconnect in μ-scale surface 'patches'



Electron "beam" input energy can be DC electric currents

Using laser input energy is an option

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Key attributes of μ-scale LENR-active 'patches'

Mesoscopic quantum effects including entanglement are very important

	Type of particle in LENR-active patch	Are particles in patch charged?	Dimensionality	Do particles collectively oscillate?	Are particles Q-M entangled?	Comments
Widom-Larsen surface patch Sizes vary randomly - diameters can range from several nm to perhaps up to ~100 microns	Surface plasmon electrons (fermions) Decidedly many-body	Yes, -	~2-D to 3-D somewhat reduced	Yes	Yes Q-M wave functions are very delocalized within a patch	Very high nuclear-strength electric fields > 2 x 10^{11} V/m present within an energized patch; this increases local SP electron masses, allowing some of them to directly react with protons in $e + p \rightarrow n + \nu$
	Surface protons (hydrogen) (fermions) Decidedly many-body	Yes, +	~2-D to 3-D somewhat reduced	Yes	Yes Q-M wave functions are very delocalized within a patch	Very high nuclear-strength electric fields > 2 x 10^{11} V/m present within an energized patch thanks to E-M coupling and breakdown of the Born-Oppenheimer approximation
Substrate material	Mostly neutral atoms except for interstitial absorbed hydrogenous ions that occupy material-specific sites in substrate bulk lattice	No charge-neutral for the most part	Essentially 3-D i.e., bulk material	No	No	When protons are 'loaded' into a hydride-forming lattice, they occupy specific interstitial sites. After site occupancies > ~0.80 , protons start 'leaking' back onto surface, forming collectively oscillating, Q-M entangled, ~2-D monolayer 'pools' of protons that E-M couple locally to surface plasmon electrons

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LENRs in condensed matter systems

List of basic experimental requirements for creating μ-scale active sites

- ✓ **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 self-organize and form spontaneously at random locations scattered across metallic hydrides' surfaces and at internal metal/oxide 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, LENRs occur in tiny surface 'patches' of contiguous collections of collectively oscillating p^+, d^+, and/or t^+ ions; B-O breakdown 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 multiples of an electron at rest ($e^- \rightarrow e^{-*}$); degree of mass-enhancement is determined by required ~simultaneous disequilibrium energy input(s); and

- ✓ **Disequilibrium input energy**: triggering LENRs requires external non-equilibrium fluxes of various charged particles or electromagnetic (E-M) radiation that transfer input energy directly to many-body SP or π electron 'plasmonic surface films'. Examples of external energy input 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 reactions.

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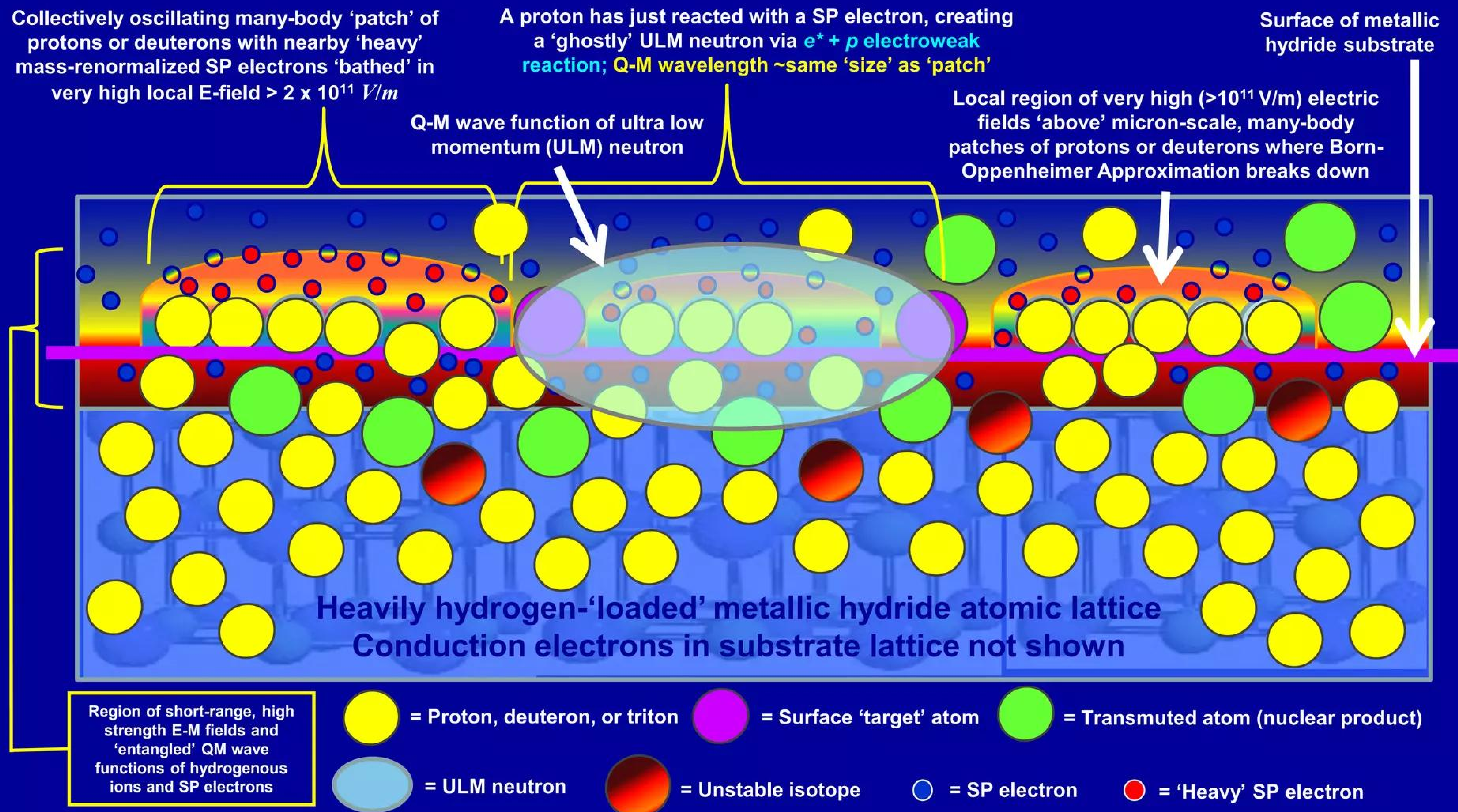
LENRs occur in micron-scale surface ‘patches’

Conceptual overview of micron-scale LENR-active sites on a surface



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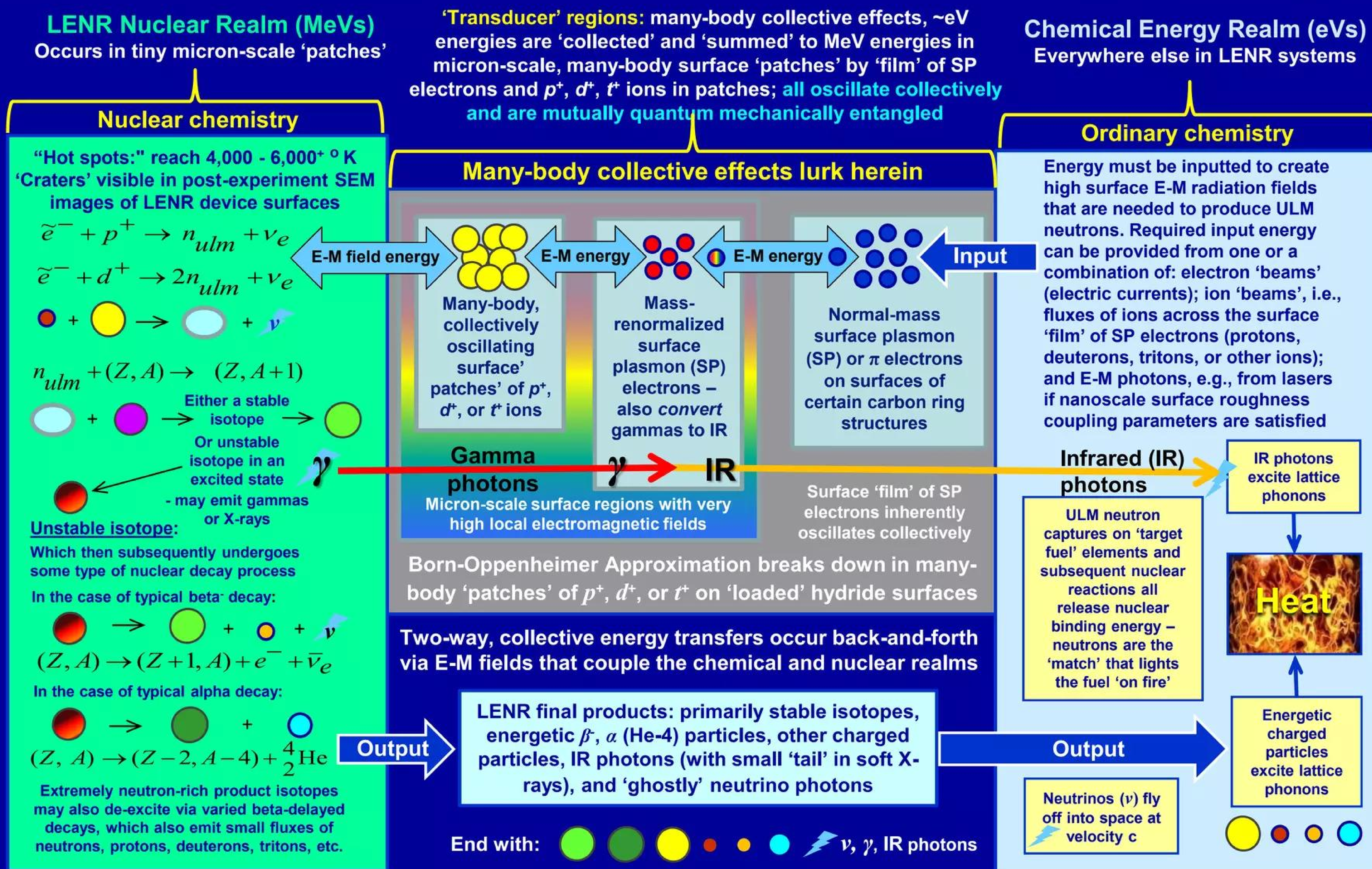
Interface between chemical and nuclear energies



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LENRs in condensed matter systems

Occur in μ-scale regions at surfaces or interfaces and on aromatic rings

- ✓ **Under proper conditions, $e + p \rightarrow n + \nu_e$ (endothermic by 0.78 MeV) electroweak "neutronization" reaction (surface plasmon SP electron reacts directly with a surface proton to make a neutron and an electron neutrino) can occur at surprisingly high reaction rates in micron-scale, monolayer, many-body 'patches' of collectively oscillating protons or deuterons that can form spontaneously on fully 'loaded' metallic hydride surfaces (bulk hydride interstitial H sites are all occupied)**
- ✓ **These surface 'patch' sites range in size from ~2 nm to ~100 microns; they can become LENR-active when sufficient amounts of E-M input energy in the right form is transported to, and concentrated in, them by wide-area 'film' of entangled SP electrons that cover entire surface of a metallic hydride device (delocalized, entangled π electrons on the 'surfaces' of hydrogenated Carbon-based aromatic rings can serve the same function as SP electrons found on metallic hydride surfaces)**

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LENRs in condensed matter systems

High electric fields in patches effectively increase masses of electrons

- ✓ **In such coherently oscillating 'patches' of surface protons, deuterons, or tritons the Born-Oppenheimer approximation breaks down; this causes electromagnetic coupling between SP electrons and protons, deuterons, or tritons associated with a 'patch' and enables local nuclear-strength, collective electric fields > 2 x 10^{11} V/m to be created therein; such a 'patch' is akin to a 'naked' pancake-shaped nucleus**
- ✓ **'Patch' SP electrons locally bathed in nuclear-strength electric fields undergo what is called "*mass renormalization*," that is, their masses effectively increase. This effect that our condensed matter theory of LENRs relies upon was first discovered and published by Russian physicists back in 1970s (Landau & Lifshitz, "*The Classical Theory of Fields*", Sects. 17 and 47, Prob. 2, Pergamon Press, Oxford 1975 and Berestetskii, Lifshitz, & Pitaevskii, "*Quantum Electrodynamics*", Sect. 40, Eq. 40.15, Butterworth Heinmann, Oxford, 1997)**

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LENRs in condensed matter systems

Many-body collective effects enable nuclear processes at low temps

- ✓ **SP electron mass-renormalization by absorbing E-M energy directly from local electric fields allows portion of SP electrons located in LENR-active 'patches' to possess enough additional mass-energy (>0.78 MeV) to cross energetic threshold for reacting collectively with local protons, deuterons, or tritons to create neutrons and neutrinos; star-like macroscopic temperatures are thus NOT required to do this**
- ✓ **Comparatively cool (in terms of macroscopic temperature regime), collective many-body field-energy-driven processes in condensed matter LENRs contrast sharply with few-body thermal kinetic processes that occur in stellar, tokamak, *Z*-pinch, and ICF fuel 'target' fusion plasmas wherein charged particles, e.g. d^+ and t^+, are heated to enormous temperatures so that a very tiny % (high-energy 'tail' of Maxwellian distribution of particle energies) of them that strike each other head-on have kinetic energy required to surmount the Coulomb energetic barrier (like charges repel each other) to nuclear fusion**

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LENRs in condensed matter systems

Collectively produced neutrons: ultra low momentum and local capture

- ✓ **Unlike energetic neutrons typically produced in nuclear reactions, collectively produced LENR neutrons are ~ 'standing still' at the moment of creation in condensed matter. Since they are vastly below thermal energies (i.e., ultra low momentum), ULM neutrons have huge Q-M DeBroglie wavelengths and commensurately large capture cross-sections on nearby nuclei; virtually all will be locally absorbed – only very rarely will some be detectable as *minute* fluxes of 'free' neutrons**
- ✓ **For vast majority of stable and unstable isotopes, effective neutron capture cross-sections (relative to measured cross-sections at thermal energies where v = 2,200 m/sec and DeBroglie wavelength is ~2 Angstroms) are directly related to ~1/*v*, where *v* is neutron velocity in m/sec. Since *v* in m/sec is negligible for ULM neutrons, their 1/*v* capture cross-sections on nuclei will be proportionately larger. After being created collectively, virtually all ULMNs will be captured locally before scattering on lattice atoms elevates them to thermal kinetic energies**

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W-L: gammas converted to IR by heavy electrons

- ✓ When an ULM neutron captures onto an atom located inside the entangled 3-D Q-M domain of an LENR-active patch, there is normally a prompt gamma photon emission by that atom. Well, remember that the DeBroglie wave functions of the entangled, mass-renormalized 'heavy' electrons are also 3-D, NOT 2-D. Since the neutron capture gamma photon emission occurs INSIDE the 3-D quantum mechanical structure of a 3-D LENR-active 'patch', there are always heavy electrons available nearby to absorb such gamma emissions and convert them directly into infrared photons. Ergo, it doesn't matter where a gamma emission occurs inside a given 3-D patch, it will always get converted to IR, which is exactly what has been observed experimentally. You will normally not observe <u>any</u> large fluxes of 'hard' gammas emitted from such a 3-D patch, no matter which x-y-z direction they may be measured from
- ✓ The above 'shielding' also applies to any gammas that might be produced in conjunction with beta-decays of unstable, extremely neutron-rich isotopes that are briefly present in LENR-active patches before they 'die.' The vast majority of these very short-lived intermediate nuclear products will have disappeared in serial cascades of beta-decay chains into end-product stable isotopes/elements before the dynamic local population of heavy-mass electrons goes completely away. Again, this prediction is very consistent with what has been long-observed experimentally: with mass spectroscopy, post-experiment you can observe the presence of stable transmutation products in which prompt capture gammas were undoubtedly produced along the likely nucleosynthetic pathway, but no 'hard' gamma fluxes can ever be measured during the process of LENR transmutation itself. Ergo, the gammas were converted to something else --- namely infrared (IR) photons that are physically manifested and measured calorimetrically as 'excess heat' from LENRs

Lattice Energy LLC

Lattice patent: revolutionary gamma shielding

(12) **United States Patent**
Larsen et al.

(10) **Patent No.: US 7,893,414 B2**
(45) **Date of Patent: Feb. 22, 2011**

(54) **APPARATUS AND METHOD FOR ABSORPTION OF INCIDENT GAMMA RADIATION AND ITS CONVERSION TO OUTGOING RADIATION AT LESS PENETRATING, LOWER ENERGIES AND FREQUENCIES**

(75) Inventors: **Lewis G. Larsen**, Chicago, IL (US); **Allan Widom**, Brighton, MA (US)

(73) Assignee: **Lattice Energy LLC**, Chicago, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 357 days.

(21) Appl. No.: **12/065,784**

(22) PCT Filed: **Sep. 8, 2006**

(86) PCT No.: **PCT/US2006/035110**

§ 371 (c)(1), (2), (4) Date: **Aug. 14, 2008**

(87) PCT Pub. No.: **WO2007/030740**

PCT Pub. Date: **Mar. 15, 2007**

(65) **Prior Publication Data**

US 2008/0296519 A1 Dec. 4, 2008

Related U.S. Application Data

(60) Provisional application No. 60/715,622, filed on Sep. 9, 2005.

(51) **Int. Cl.**
G21F 7/00 (2006.01)

(52) **U.S. Cl.** **250/515.1**; 250/505.1

(58) **Field of Classification Search** 250/505.1, 250/515.1
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,887,042 A 3/1999 Akamatsu et al.

OTHER PUBLICATIONS

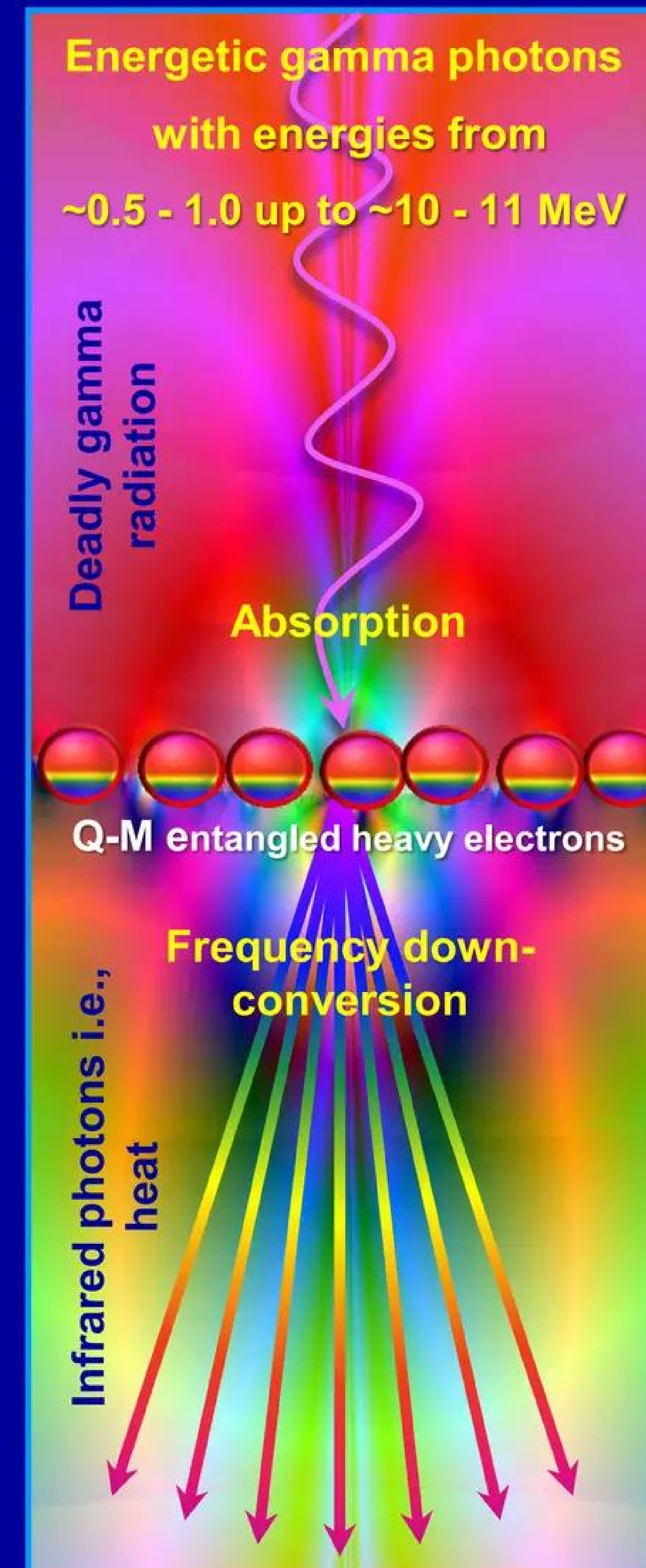
International Search Report re application No. PCT/US2006/035110, dated Mar. 14, 2007.
Written Opinion re application No. PCT/US2006/035110, dated Mar. 14, 2007.

Primary Examiner—Robert Kim
Assistant Examiner—Hanway Chang
(74) *Attorney, Agent, or Firm*—Edward D. Manzo; Husch Blackwell LLP

(57) **ABSTRACT**

Gamma radiation (**22**) is shielded by producing a region of heavy electrons (**4**) and receiving incident gamma radiation in such region. The heavy electrons absorb energy from the gamma radiation and re-radiate it as photons (**38**, **40**) at a lower energy and frequency. The heavy electrons may be produced in surface plasmon polaritons. Multiple regions (**6**) of collectively oscillating protons or deuterons with associated heavy electrons may be provided. Nanoparticles of a target material on a metallic surface capable of supporting surface plasmons may be provided. The region of heavy electrons is associated with that metallic surface. The method induces a breakdown in a Born-Oppenheimer approximation Apparatus and method are described.

23 Claims, 24 Drawing Sheets



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Experimental evidence for gamma conversion

Quoted from Columns 26 and 27 in Lattice's issued fundamental patent US #7,893,414 B2:

"In an apparatus embodying the present invention, the mean free path of a gamma photon with an energy of ~0.5 MeV and ~10.0 MeV can be (and preferably is) extraordinarily short: ~3.4 x 10^{-8} cm, or less than a nanometer. This property has the effect of suppressing emission of externally detectable gamma radiation by the invented apparatus and shielding against incident gamma radiation emanating from external sources in almost any direction. Depending on the specifics of the preferred apparatus, selected materials, and operating conditions, what may be observed experimentally can include:

- ✓ **No significant gamma emissions, mostly just internally absorbed infrared (IR) radiation and charged particle interactions (produced by LENRs) with lattice phonons. Together, they are detected as substantial amounts of measured "excess heat" in a calorimeter; such excess heat would typically be accompanied by various types of nuclear transmutation products; in addition, this may sometimes be accompanied by small, barely detectable fluxes of soft X-rays [Reference Example: "*Large excess heat production in Ni-H systems*," Focardi *et al.*, *Il Neuvo Cimento* 111, No. 11, November 1998 - this body of Italian experimental work sometimes produced large thermal fluxes]**

- ✓ **Significant numbers of nuclear transmutation products in conjunction with little or no measurable excess heat, no detectable gamma emissions, and no detectable soft X-rays [Reference Example: "*Elemental analysis of Pd complexes: Effects of D_2 gas permeation*," Iwamura *et al.*, *Japanese Journal of Applied Physics* 41, No. 7A, pp. 4642 – 4650, July 2002]**

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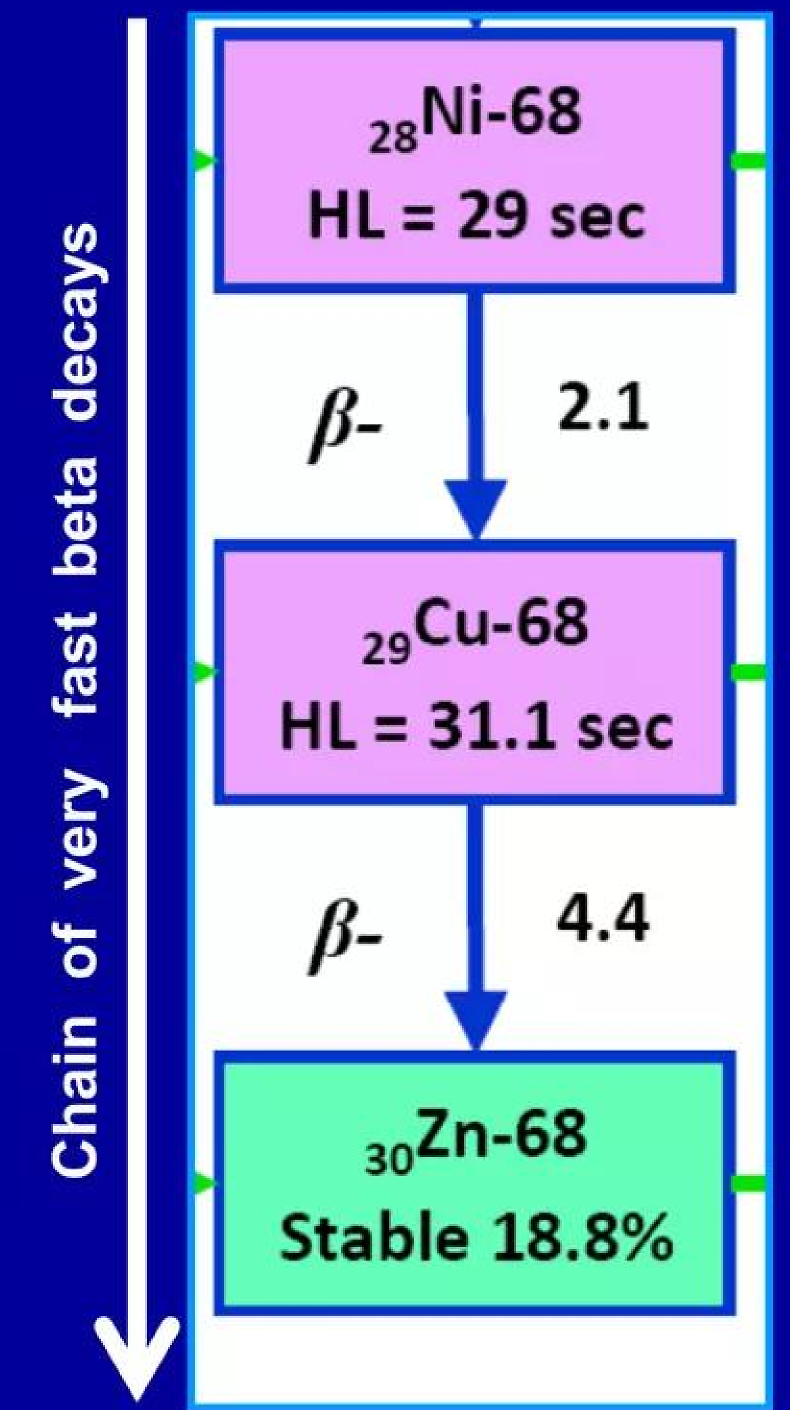
Little or no production of long-lived radioisotopes

Neutron-rich products decay very rapidly into various stable isotopes

- ✓ **Fluxes of ULM neutrons will cause a build-up of local populations of unstable, *very* neutron-rich isotopes comprising intermediate LENR transmutation products**
- ✓ **At some point during limited lifetime of an LENR-active 'patch', almost all such isotopes present in it will decay, mainly by series of very rapid *β*-decay cascades**
- ✓ **Depending on the half-lives (HL) of intermediate LENR products, ULMN captures + β^- decay chains can rapidly traverse entire rows of the periodic table, finally ending with production of almost invariably stable isotopes of higher-Z elements (see example of Ni-68 to right)**
- ✓ **This phenomenon is reason why LENR typically do not produce biologically significant amounts of "radwaste"**



Nickel-68, a product of neutron captures on stable Nickel isotopes, decays rapidly to stable Zinc

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Surface patches: hydrogenous atoms self-organize

- ✓ *"Hydrogen absorption and diffusion on Pd(111)"*
  T. Mitsui *et al.*
  Surface Science 540 pp. 5 - 11 (2003)
  http://144.206.159.178/ft/976/183940/4699801.pdf

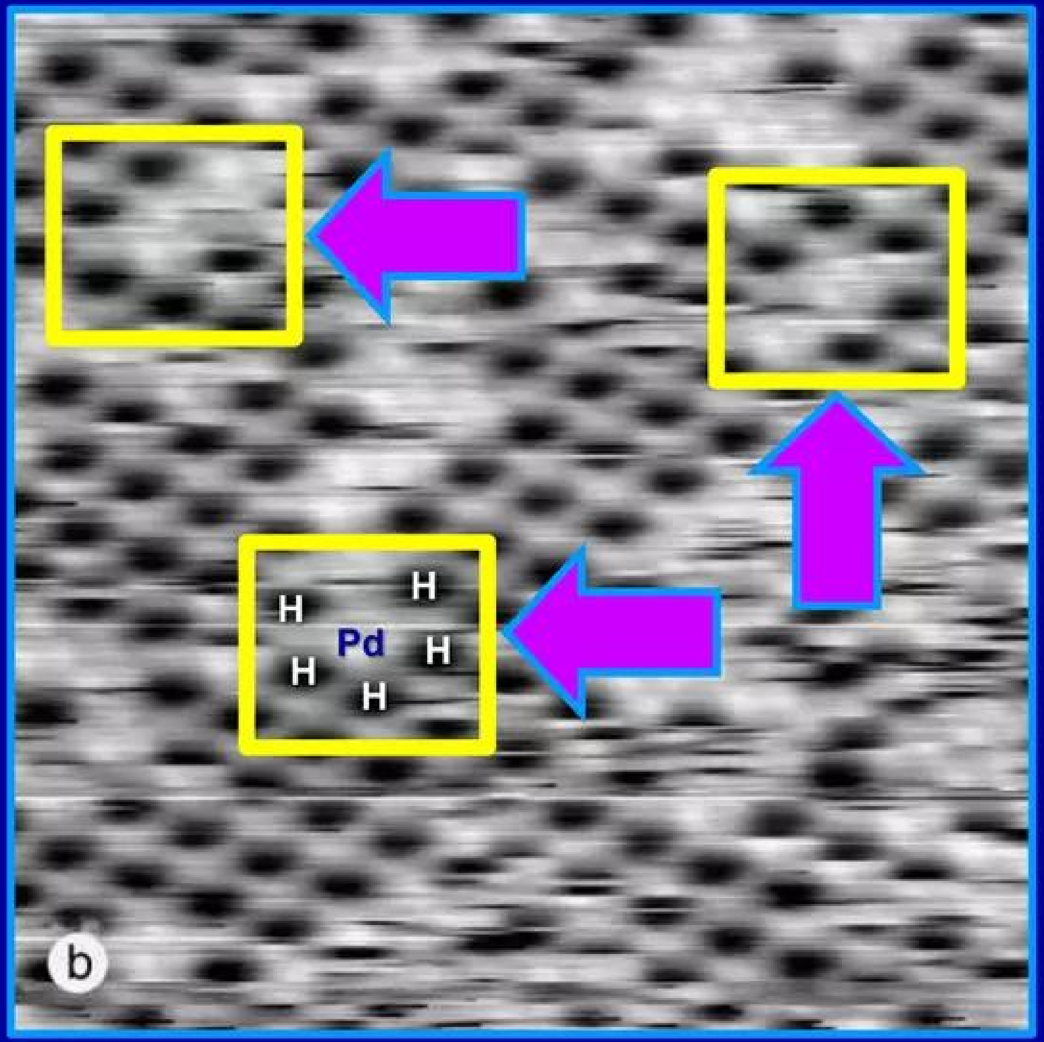
  Abstract: "The adsorption, diffusion and ordering of hydrogen on Pd(111) was studied by scanning tunneling microscopy in the temperature range of 37 - 90 K. At low coverage isolated hydrogen atoms were observed. They formed √3 x √3-1H islands as the coverage increased. Above 1/3 monolayer (ML) coverage areas of a new phase with √3 x √3 -2H structure were formed, with both structures coexisting between 1/3 and 2/3 ML. Finally a 1 x 1 structure was formed after high exposures of hydrogen above 50 K, with a coverage close to 1 ML. Atomically resolved images reveal that H binds to fcc hollow sites."

  Quoting an excerpt therefrom: "… to our knowledge, an STM study of hydrogen adsorption on a closed packed (111) metal surface has [previously] not been reported."

- ✓ Lattice comment: image at right shows many-body 'patches' of protons on a surface. Visual inspection of STM image in adapted version of Fig. 1 reveals that under Mitsui *et al.'s* experimental conditions, PdHx ratios at many surface sites would appear to be comfortably above the minimal critical value of H/Pd > 0.80 necessary for LENR triggering. In fact, PdHx H/Pd ratios at some sites can apparently range perhaps as high as x = 5.0 (again, see Figure 1. to right)

  Therefore, similarly high PdHx ratios would seem to be plausible in the case of high % surface coverage of hydrogen atoms (protons) on fully 'loaded' Pd(111) surfaces at room temperature of 273 K and beyond. Thus, high PdHx ratios could reasonably be expected to occur within the many-body, entangled hydrogenous 'patches' conjectured in the Widom-Larsen theory of LENRs

STM image of H on Pd(111) adapted from: Fig. 1 in Mitsui *et al.*, *Surface Science* (2003)



Quoting from Fig. 1 caption in paper: "Fig. 1. (a) 10 x 10 nm image of the Pd(111) surface after a short exposure to H_2 gas. Isolated H atoms are the dark spots, corresponding to 15 pm depressions. The atoms diffuse thermally and also by the influence of the tip, forming the dark streaks seen in the image. (b) At a coverage of 0.2 ML islands with √3 x √3 *R*30° structure are formed. The H atoms are now stable and do not diffuse. The influence of the tip is now negligible. The Pd atoms are the bright spots between the H islands, with a corrugation of ~2 pm. The H site, at the center of an upward pointing triangle of Pd atoms is the fcc hollow. Tunneling conditions: ~45 mV tip bias and 11 nA current."

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Surface patches: Born-Oppenheimer breakdown

Phenomenon is very well-established experimentally

Phenomenon is well-established and measured experimentally:

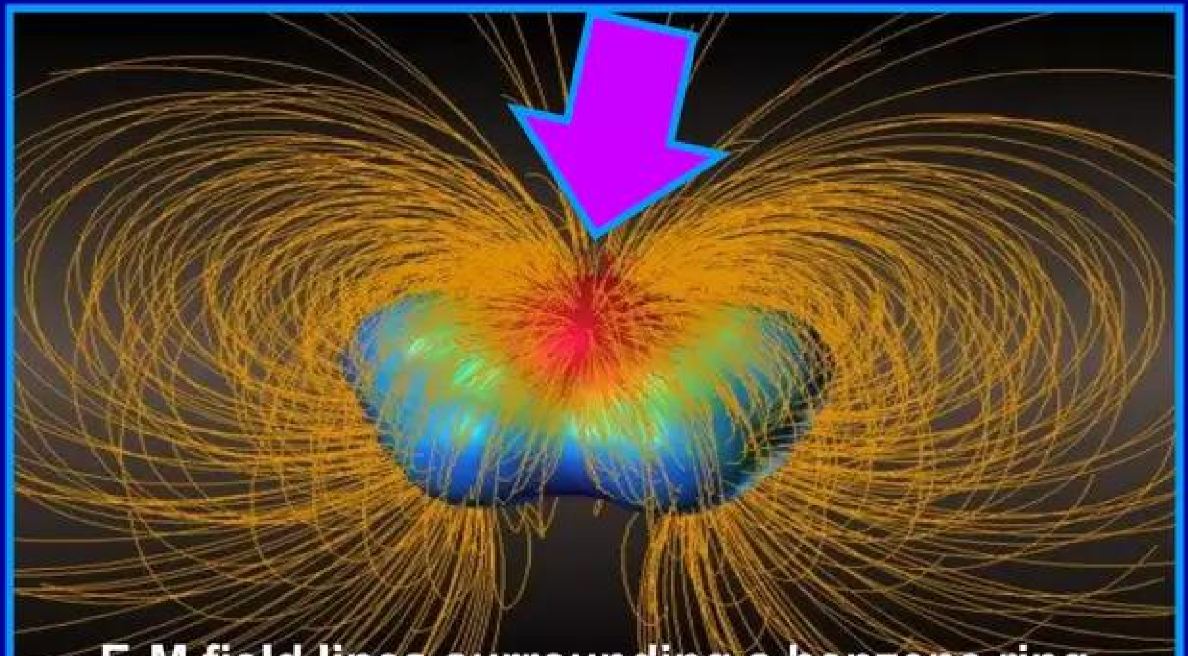
- ✓ **Born-Oppenheimer approximation is now known to break down on surfaces of carbon fullerene structures and graphene (directly observed by Bushmaker *et al*., 2009);**
- ✓ **Carbon-arc experiments of Bockris & Sundaresan and Singh *et al.* (1994) provide evidence that that LENRs and the W-L ULM carbon-seed nucleosynthetic network can occur in presence of complex mixtures of fullerenes and graphene (see Larsen 9/3/09)**
- ✓ **Born-Oppenheimer is well known to break down on metal surfaces; quoting Yale Prof. John Tully, "Breakdown of the Born-Oppenheimer assumption is the rule rather than the exception in electron transfer reactions, photochemistry, and reactions at metal surfaces." (please see his website at right)**
- ✓ **Born-Oppenheimer also known to break down in benzene rings in conjunction with quantum entanglement of protons on those rings (see Chatzidimitriou- Dreismann & Mayers, 2002). Quoting from their paper, "… our NCS results …indicate that the physical meaning of … Born-Oppenheimer [approximation] should be critically reconsidered … at least for chemical processes in the …femtosecond time scale … [we also] demonstrate that short-lived protonic quantum entanglement and decoherence are of much broader significance than realized thus far."**

➡ ***"Direct observation of Born-Oppenheimer approximation breakdown in carbon nanotubes"***
Bushmaker *et al.*
***Nano Letters* 9 pp. 607 (2009)**

➡ **See Lattice Energy LLC SlideShare presentation dated September 3, 2009, at:**
http://www.slideshare.net/lewisglarsen/lattice-energy-llctechnical-overviewcarbon-seed-lenr-networkssept-3-2009

➡ **See Prof. Tully's Yale website at:**
http://www.chem.yale.edu/~tully/research.html

➡ ***"Sub-femtosecond dynamics and dissociation of C-H bonds in solid polystyrene and liquid benzene"***
C. Chatzidimitriou-Dreismann & Mayers
***Journal of Chemical Physics* 116 pp. 1617-1623 (2002)**



E-M field lines surrounding a benzene ring

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Surface patches: many-body collective oscillations

There is mutual mesoscopic quantum entanglement of e^- and p^+, d^+, t^+

- ✓ **Many-body collective oscillations and mutual quantum entanglement of protons (as well as deuterons and tritons) and electrons (e.g., SPs on metallic hydride surfaces), in conjunction with a breakdown of the Born-Oppenheimer approximation, appear to be relatively common in nature, occurring in many different types of physical systems**

- ✓ **While these many-body collective processes chronicled by Chatzidimitriou-Dreismann *et al.* operate very rapidly and nanoscale Q-M coherence can only persist for time spans on the order of femtoseconds (10^{-15} sec) to attoseconds (10^{-18} sec), nuclear processes such as weak interaction ULM neutron production and neutron capture operate on even faster time-scales: 10^{-19} to 10^{-22} sec. Therefore, LENRs as explained by the Widom-Larsen theory can easily take advantage of such many-body collective quantum effects as an integral part of their amazing dynamical repertoire**

- ✓ **It is well-known that metallic surface nanostructures and SP electrons can have configurations that are able to effectively absorb E-M energy over a wide area, transfer and concentrate it, and in conjunction with contiguous surface 'patches' of collectively oscillating protons, create nuclear-strength local electric fields. According to W-L theory of LENRs, electroweak neutron production can then follow**

→ **C. Chatzidimitriou-Dreismann (Technical University of Berlin) and his collaborators have published extensively on collective proton dynamics since 1995. Please also see:**

***"Attosecond quantum entanglement in neutron Compton scattering from water in the keV range"* (2007); can be found at**

http://arxiv.org/PS_cache/cond-mat/pdf/0702/0702180v1.pdf

"Several neutron Compton scattering (NCS) experiments on liquid and solid samples containing protons or deuterons show a striking anomaly, i.e. a shortfall in the intensity of energetic neutrons scattered by the protons; cf. [1, 2, 3, 4]. E.g., neutrons colliding with water for just 100 - 500 attoseconds (1 as = 10^{-18} s) will see a ratio of hydrogen to oxygen of roughly 1.5 to 1, instead of 2 to 1 corresponding to the chemical formula H_2O. … Recently this new effect has been independently confirmed by electron-proton Compton scattering (ECS) from a solid polymer [3, 4, 5]. The similarity of ECS and NCS results is striking because the two projectiles interact with protons via fundamentally different forces, i.e. the electromagnetic and strong forces."

→ **Also: *"Entangled mechanical oscillators,"* J. Jost *et al.*, *Nature* 459 pp. 683 - 685 4 (2009) in which, "... mechanical vibration of two ion pairs separated by a few hundred micrometres is entangled in a quantum way."**

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Surface patches: many-body collective systems

Phenomenon is very well-established experimentally

Phenomenon is well-established; measured experimentally:

- ✓ **Protons found within a wide variety of many-body molecular systems spontaneously oscillate coherently/collectively; their quantum mechanical (QM) wave functions are thus effectively entangled with each other and also with nearby collectively oscillating electrons; amazingly, this behavior occurs even in comparatively 'smaller,' 'simpler' molecular systems such as $(NH_4)_2PdCl_6$, ammonium hexaclorometallate (see Krzystyniak *et al*., 2007 and Abdul-Redah & Dreismann, 2006). Quoting from the paper by Krzystyniak *et al*., "… different behaviors of the observed anomaly were found for LaH_2 and LaH_3 … As recognized by Chatzidimitriou-Dreismann *et al.* Coulombic interaction between electrons and protons may build up entanglement between electrons and protons. Such many body entangled states are subject to decoherence mechanisms due to the interaction of the relevant scattering systems with its environment … one can conclude that the vibrational dynamics of NH_4^+ protons as fairly well decoupled from the dynamics of the [attached] heavier nuclei."**

- ✓ **Elaborating further from Chatzidimitriou-Dreismann (2005), "Further NCS experiments confirmed the existence of this effect in quite different condensed matter systems, e.g., urea dissolved in D_2O, metallic hydrides, polymers, 'soft' condensed matter, liquid benzene, and even in liquid H_2-D_2 and HD."**

➡ ***"Anomalous neutron Compton scattering cross sections in ammonium hexachlorometallates,"*** **Krzystyniak *et al., Journal of Chemical Physics* 126 pp. 124501 (2007)**

➡ ***"Irreversible hydrogen quantum dynamics and anomalous scattering behavior in liquids and solids,"*** **Abdul-Redah & Chatzidimitriou-Dreismann, *International Journal of Hydrogen Energy* 31 pp. 269 - 276 (2006)**

➡ ***"Attosecond protonic quantum entanglement in collision experiments with neutrons and electrons,"*** **C. Chatzidimitriou-Dreismann, *Laser Physics* 15 pp. 780 -788 (2005)**

➡ **Please also see book chapter by Chatzidimitriou-Dreismann *et al.*, *"Attosecond effects in scattering of neutrons and electrons from protons"*, in Decoherence, Entanglement, and Information Protection in Complex Quantum Systems, Akulin *et al.* eds., NATO Science Series II Vol. 189 Springer Netherlands (2005)**

With regard to direct experimental evidence that surface plasmons are quantum mechanically entangled, see:

➡ ***"Plasmon-assisted transmission of entangled photons,"*** **E. Altewischer *et al., Nature* 418 pp. 304 - 306 (2002); quoting from it, "Our coincidence counting measurements show that it does [quantum entanglement of photons survives its conversion to surface plasmons], so demonstrating that surface plasmons have a true quantum nature … simple estimate shows that SPs are very macroscopic, in the sense that they involve 10^{10} electrons . Our experiment proves that this macroscopic nature does not impede the quantum behavior of SPs… "**

http://www.molphys.leidenuniv.nl/~exter/articles/nature.pdf

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Surface patches: quantum entanglement of protons

Phenomenon is very well-established experimentally

"Evidence of macroscopically entangled protons in a mixed isotope crystal of $KH_pD_{1-p}CO_3$"
F. Fillaux, A. Cousson, and M. Gutmann
Journal of Physics - Condensed Matter 22 pp. 045402 (2010)
http://hal.archives-ouvertes.fr/docs/00/44/62/16/PDF/Fillaux.pdf

Quoting directly:

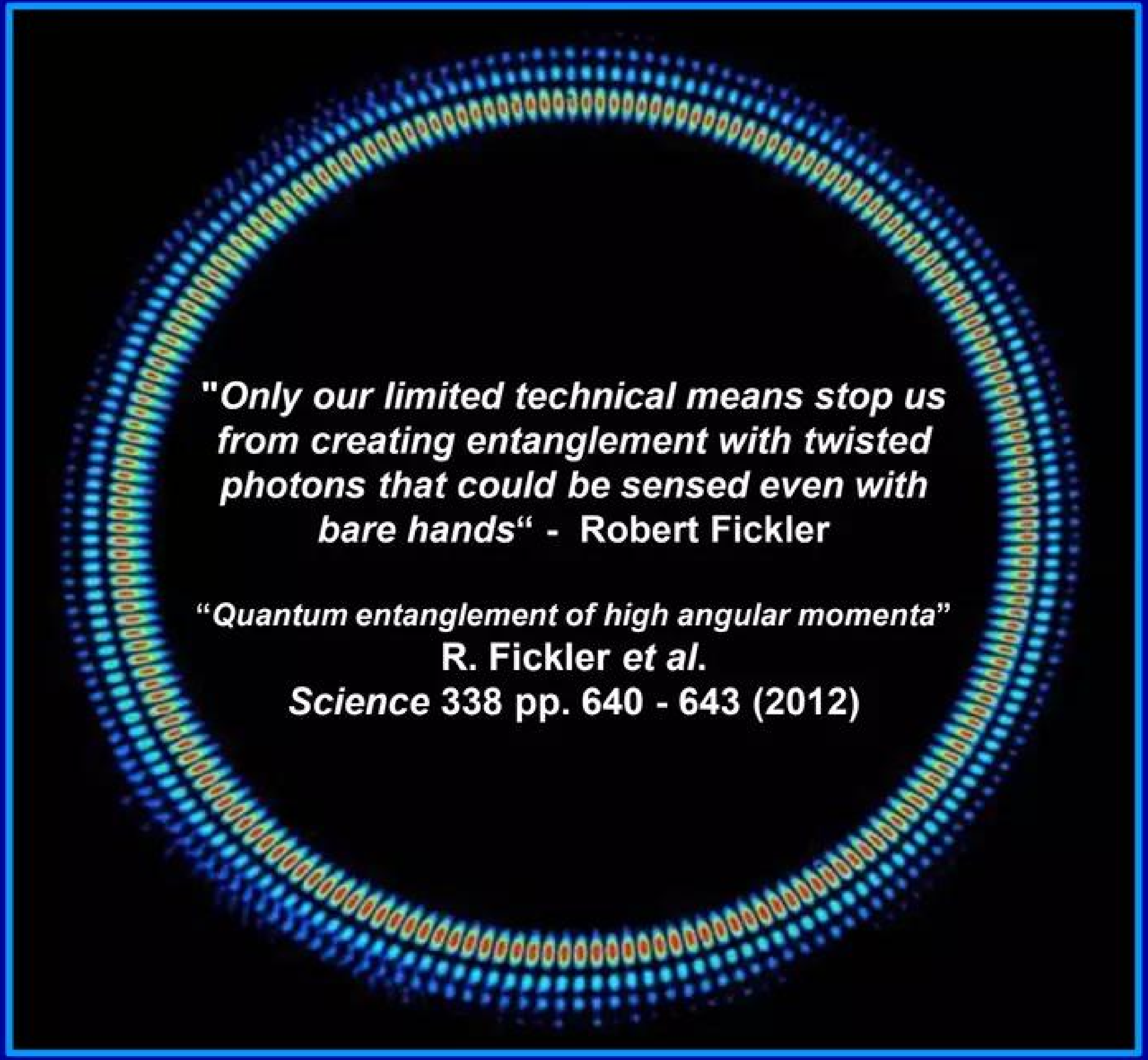
"The proposed theory is based upon fundamental laws of quantum mechanics applied to the crystal in question: the structure is periodic; dimers are centrosymmetric; indistinguishable protons are fermions; indistinguishable deuterons are bosons. It leads to macroscopically entangled states and, in the special case of protons, to super-rigidity and spin-symmetry with observable consequences. This theory is consistent with a large set of experimental data (neutron diffraction, QENS, INS, infrared and Raman) and, to the best of our knowledge, there is no conflict with any observation. There is, therefore, every reason to conclude that the crystal is a macroscopic quantum system for which only nonlocal observables are relevant."

"Protons are unique to demonstrating quantum entanglement, because they are fermions and because the very large incoherent cross-section can merge into the total coherent cross-section. No other nucleus can manifest such an increase of its coherent cross-section. The enhanced features can be, therefore, unambiguously assigned to protons, in accordance with their positions in reciprocal space. They are evidences of macroscopic quantum correlations which have no counterpart in classical physics."

"This work presents one single case of macroscopically entangled states on the scale of Avogadro's constant in a mixed isotope crystal at room temperature. The quantum theory suggests that such macroscopic quantum effects should be of significance for many hydrogen bonded crystals."

Also please see:

"A neutron diffraction study of macroscopically entangled proton states in the high temperature phase of the $KHCO_3$ crystal at 340 K"
F. Fillaux, A. Cousson, and M. Gutmann
Journal of Physics - Condensed Matter 20 pp. 015225 (2008)
http://www.ladir.cnrs.fr/pages/fillaux/159_JPCM_2008_015225.pdf



False Color Image of Laser Beam Superimposition of Entangled Photons
Credit: R. Fickler, Univ. of Vienna

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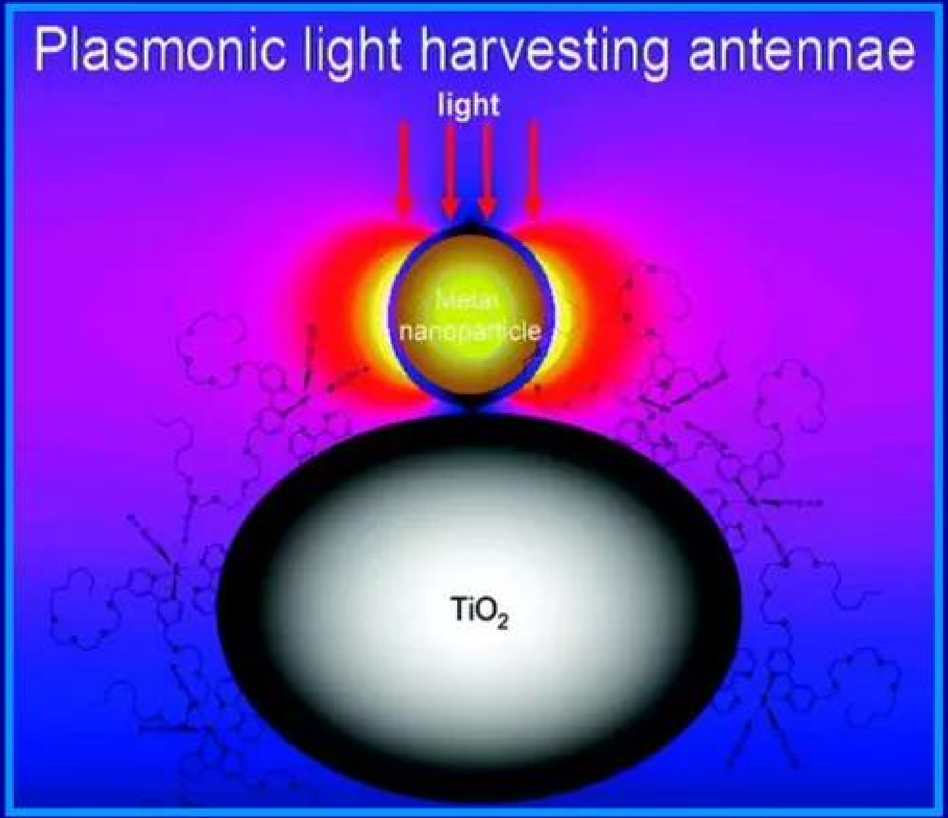
Surface patches: nanoparticles as E-M antennas

Capture, concentrate, and readily transport electromagnetic energy

- ✓ **Pucci *et al.* (2008): "If metal structures are exposed to electromagnetic radiation, modes of collective charge carrier motion, called plasmons, can be excited … Surface plasmons can propagate along a distance of several tens of micrometers on the surface of a film."**
- ✓ **"In the case of one nanoparticle, the surface plasmon is confined to the three dimensions of the nanostructure and it is then called localized surface plasmon (LSP). In this situation, the LSP resonance depends on the metallic nature (effect of the metal permittivity) and on the geometry (effect of the confinement of the electron cloud) of the nanostructure."**
- ✓ **"If the smallest dimension of the particle is much larger than the skin depth of the electromagnetic radiation in the metal, also real metal wires can be estimated as perfect conductors. For ideal metal objects it is assumed that the light does not penetrate into the particle. This means an infinitely large negative dielectric function. Then, antenna-like resonances occur if the length L of an infinitely thin wire matches with multiples of the wavelength λ."**
- ✓ **"Electromagnetic scattering of perfect conducting antennas with D smaller than the wavelength and L in the range of the wavelength is discussed in classical antenna scattering theory … It is a frequently used approximation to consider a metal nanowire as an ideal antenna. This approach has been proposed also for the modeling of nanowires in the visible spectral range …"**
- ✓ **"… field is enhanced at the tip of the nanowire when the excitation wavelength corresponds to an antenna mode … the end of the nanowires in a relatively sharp and abrupt surface is a perfect candidate to host a lightning rod effect ..." [N.B. - huge localized E-fields created near sharp tips]**
- ✓ **"… for metallic wires larger than several hundred nanometers. The increasing size of the nanoantennas makes the resonances to appear at wavelengths that present larger negative values of the dielectric function, i.e. for wavelengths well in the mid infrared portion of the spectrum in the case of micron-sized wires. It is actually this extension of the resonant behavior to micron-sized antennas what makes these structures optimal candidates for surface enhanced Raman spectroscopy (SERS) and surface-enhanced infrared absorption spectroscopy (SEIRA)."**

Reference for Pucci *et al.*:

***"Electromagnetic nanowire resonances for field-enhanced spectroscopy,"* Chap. 8 in *"One-Dimensional Nanostructures,"* Pucci *et al.*, Series: Lecture Notes in Nanoscale Science and Technology, V. 3, Wang, Zhiming M. (Ed.), Springer pp. 178-181 (2008)**



http://people.ccmr.cornell.edu/~uli/res_optics.htm

Source of above image is the Wiesner Group at Cornell University:

See: *"Plasmonic dye-sensitized solar cells using core-shell metal-insulator nanoparticles,"* M. Brown *et al.*, *Nano Letters* 11 (2) pp. 438 - 445 (2011)

http://pubs.acs.org/doi/abs/10.1021/nl1031106

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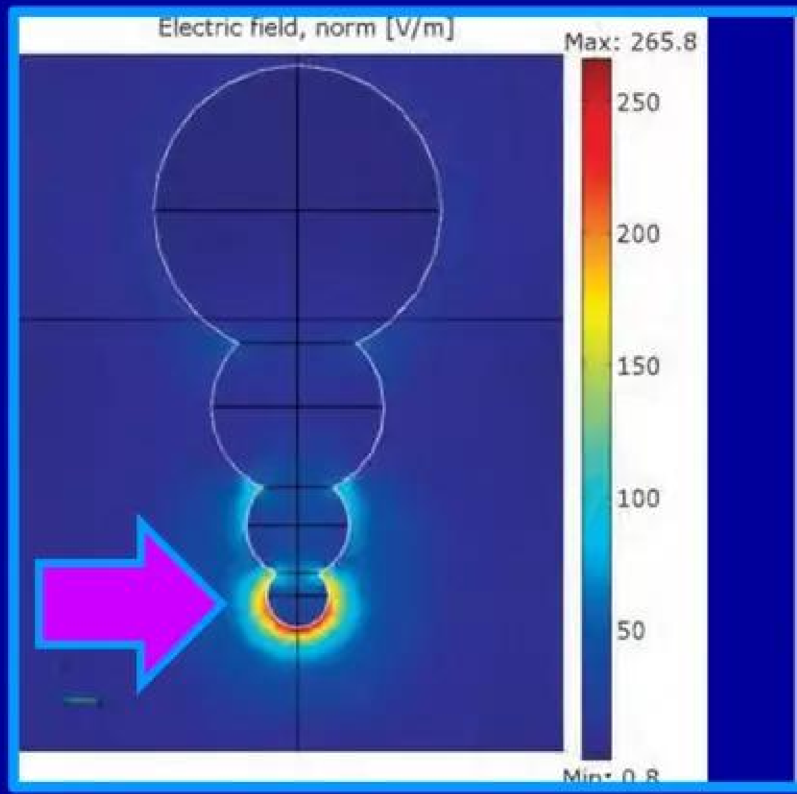
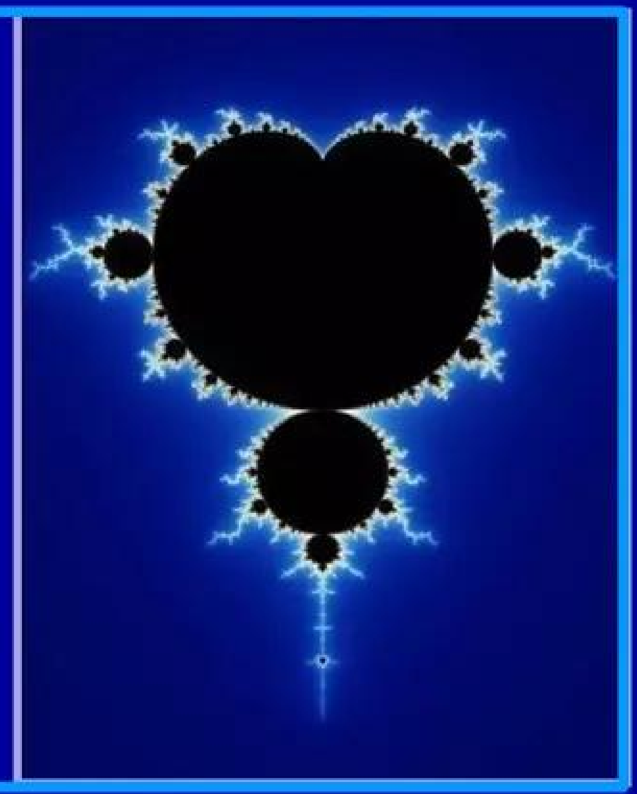
Surfaces of nanoparticles are very important

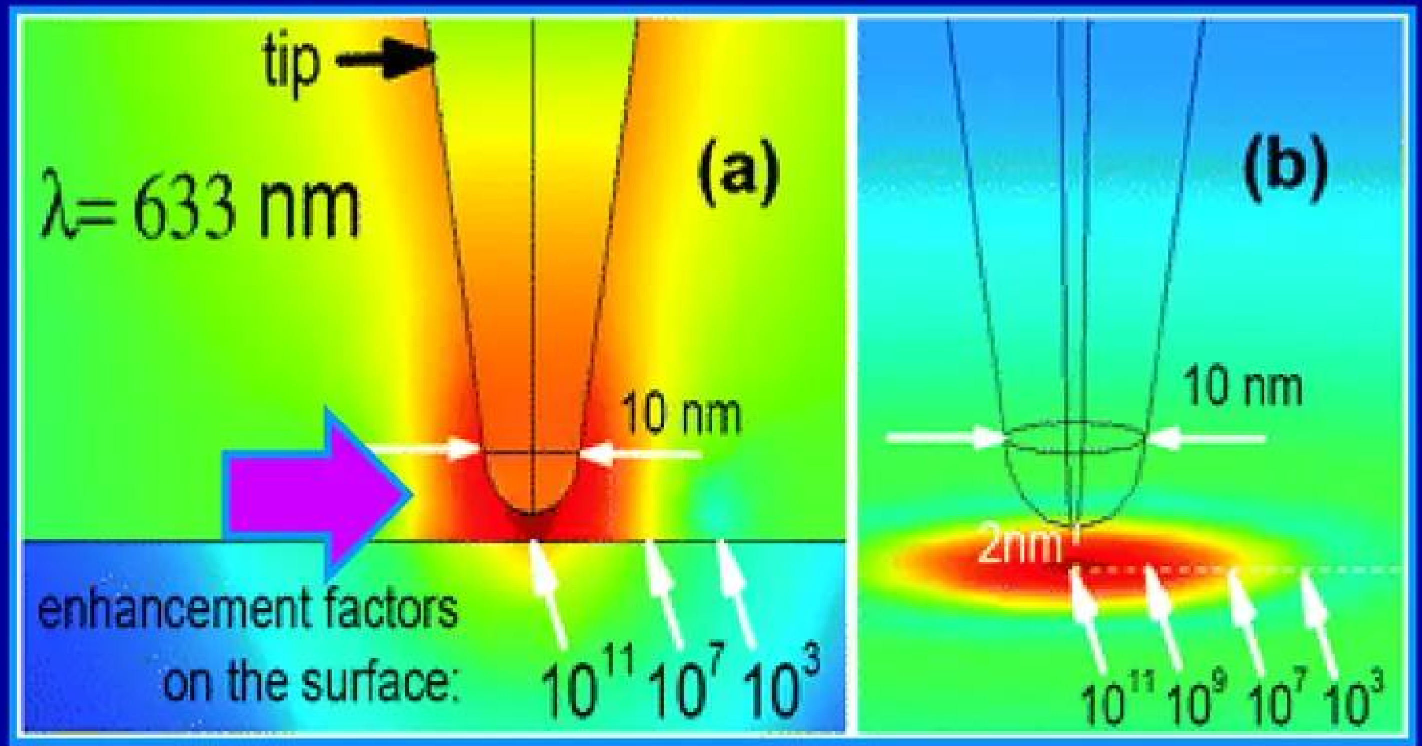
Greatly amplify electromagnetic fields in spatially localized regions





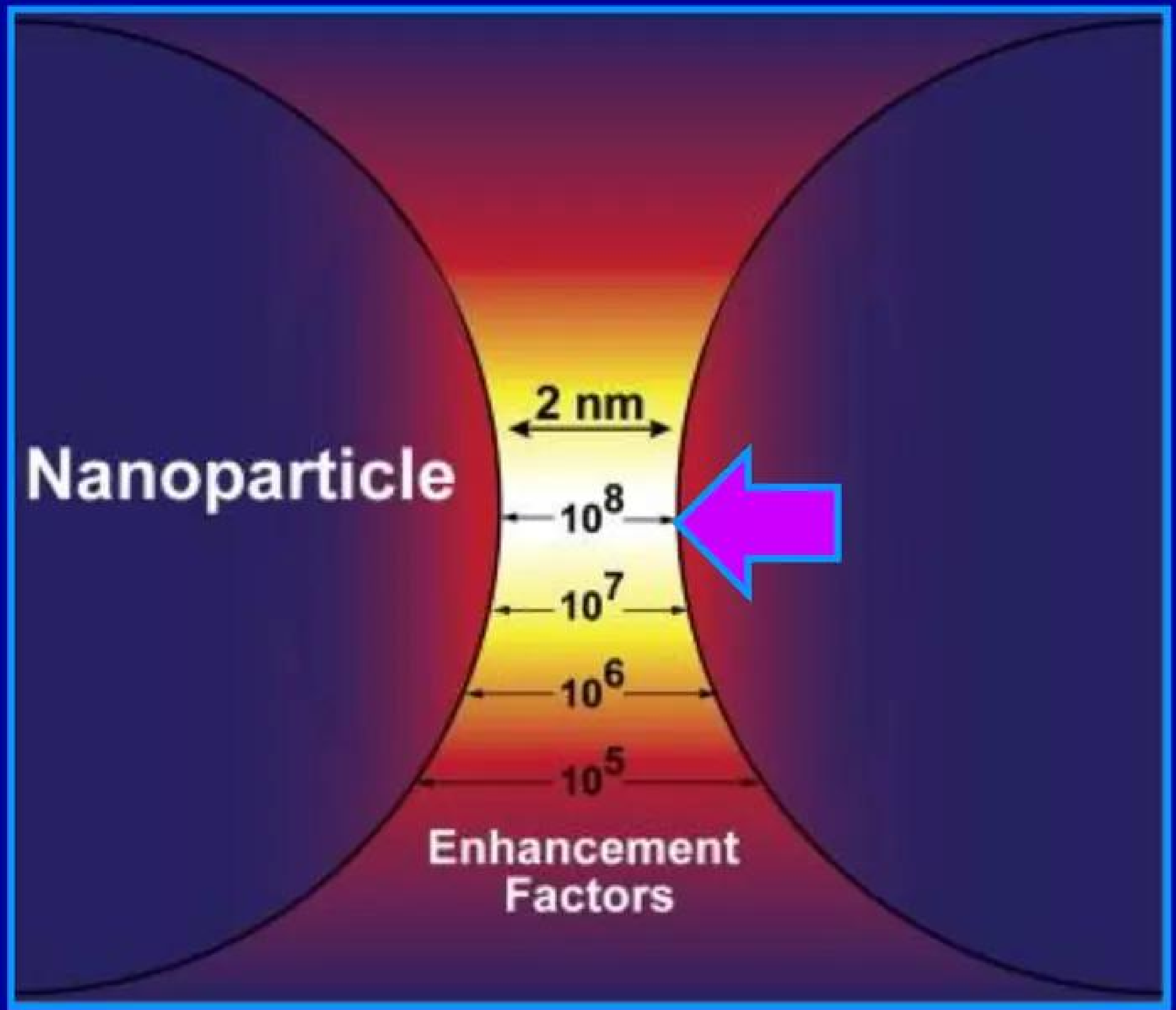
Electric field enhancement at nano-antenna tip: R. Kappeler *et al.*, 2007

Above: classic Mandelbrot fractal form



Sharp tips can exhibit the so-called "lightning rod effect" in terms of local enhancement of electric field strengths

E-M field strength enhancement as a function of interparticle spacing



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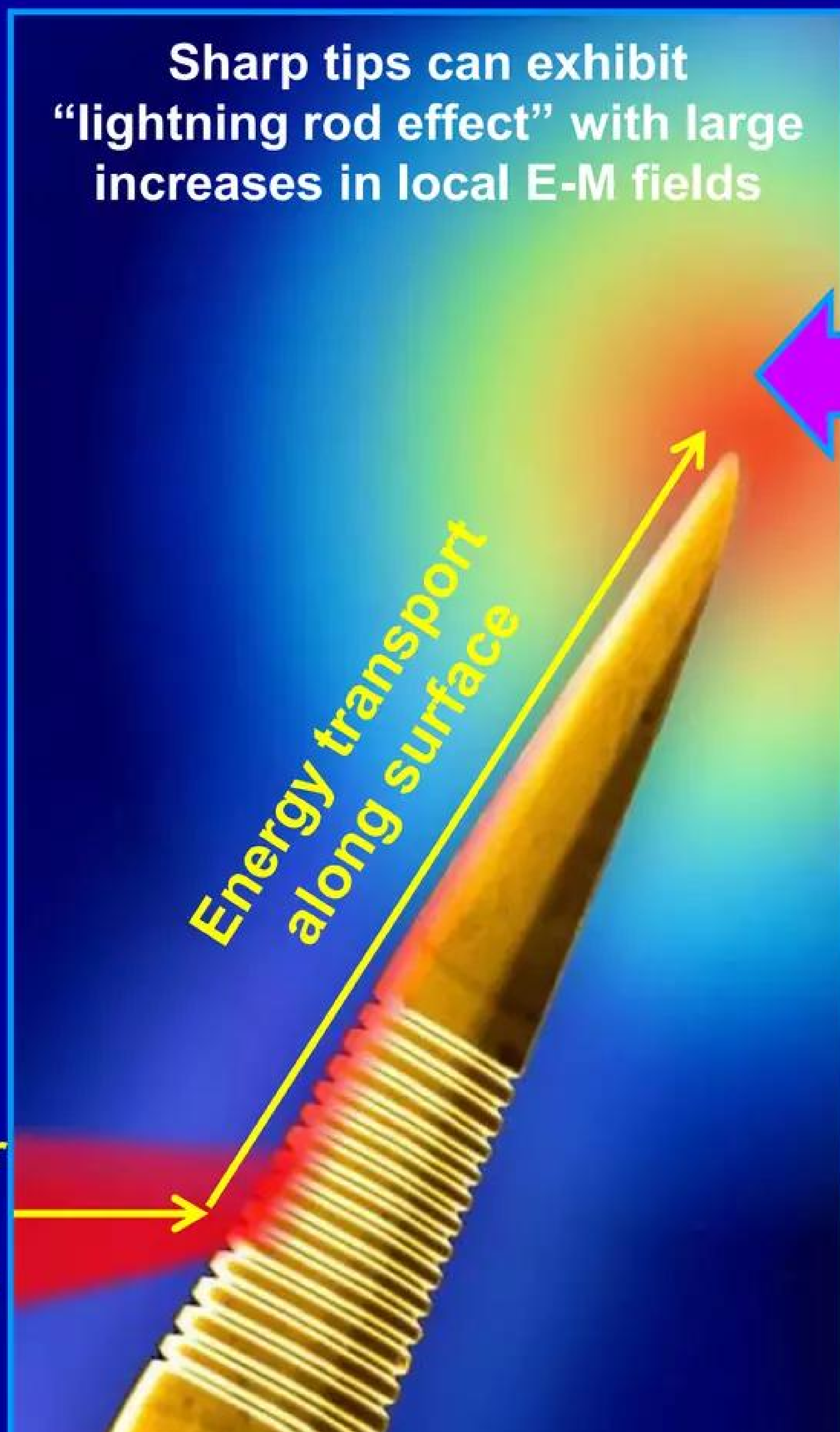
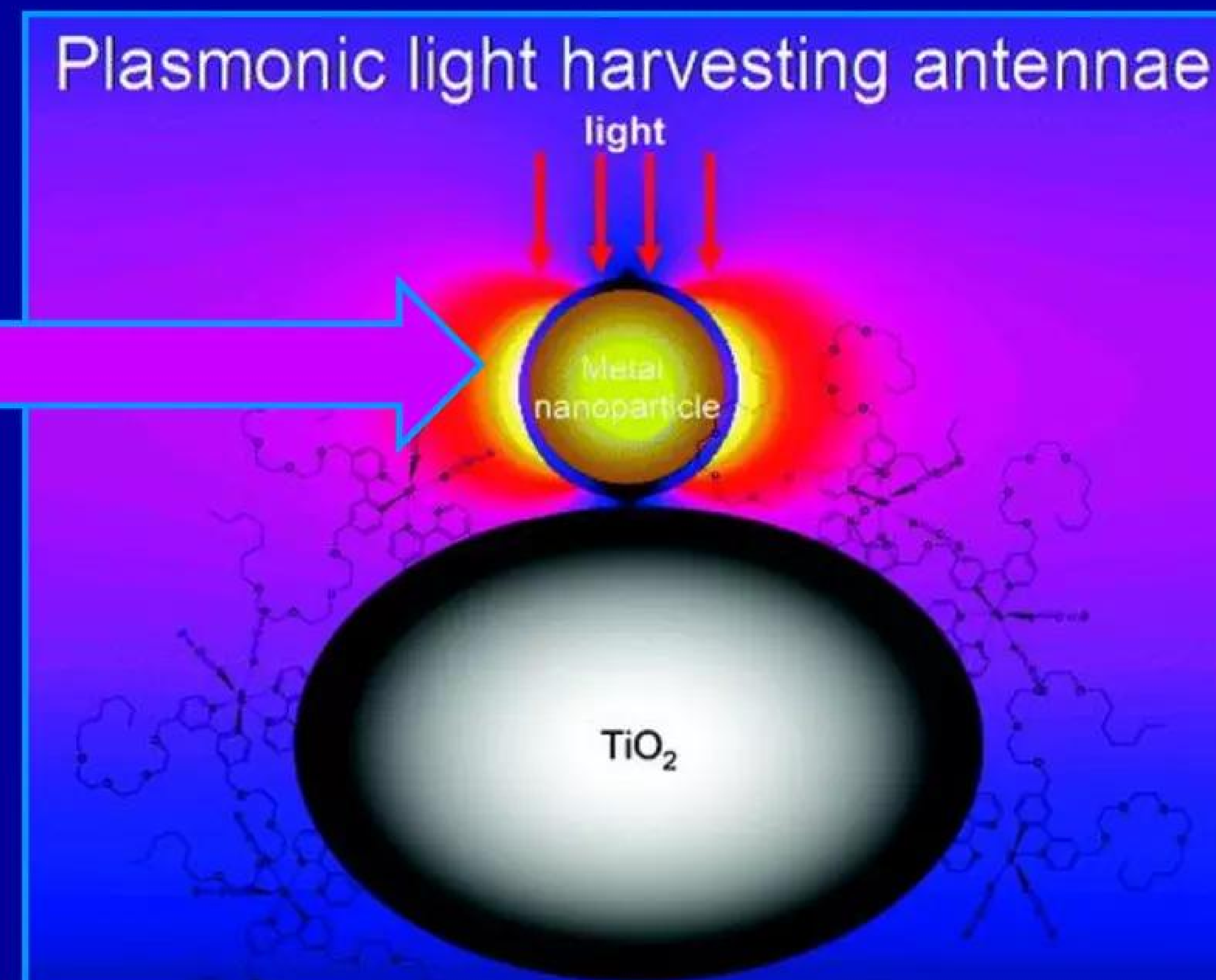
Engineered nanoparticles key to controlling fields

Capture, concentrate, and readily transport electromagnetic energy



E-M laser 'beam' photons

Regions of super-enhanced E-M fields



http://people.ccmr.cornell.edu/~uli/res_optics.htm

<u>Source of above image is the Wiesner Group at Cornell University</u>:

See: "*Plasmonic dye-sensitized solar cells using core-shell metal-insulator nanoparticles,*" M. Brown *et al.*, *Nano Letters* 11 (2) pp. 438 - 445 (2011) http://pubs.acs.org/doi/abs/10.1021/nl1031106

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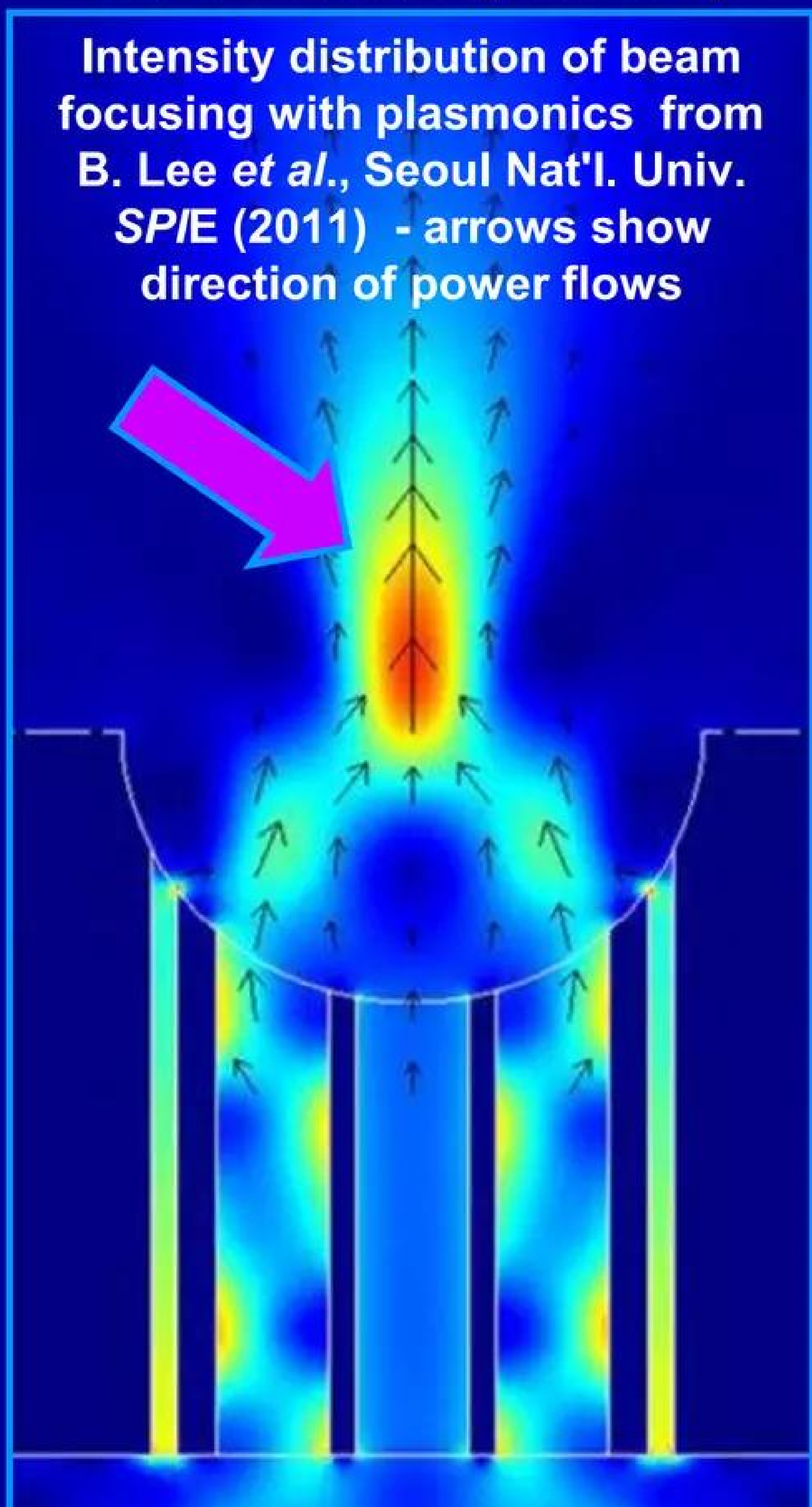
Resonant E-M cavities are also important

Focus energy locally and can have non-radiating 'storage' modes

Concentrating E-M energy in resonant electromagnetic cavity



Intensity distribution of beam focusing with plasmonics from B. Lee *et al*., Seoul Nat'l. Univ. *SPI*E (2011) - arrows show direction of power flows

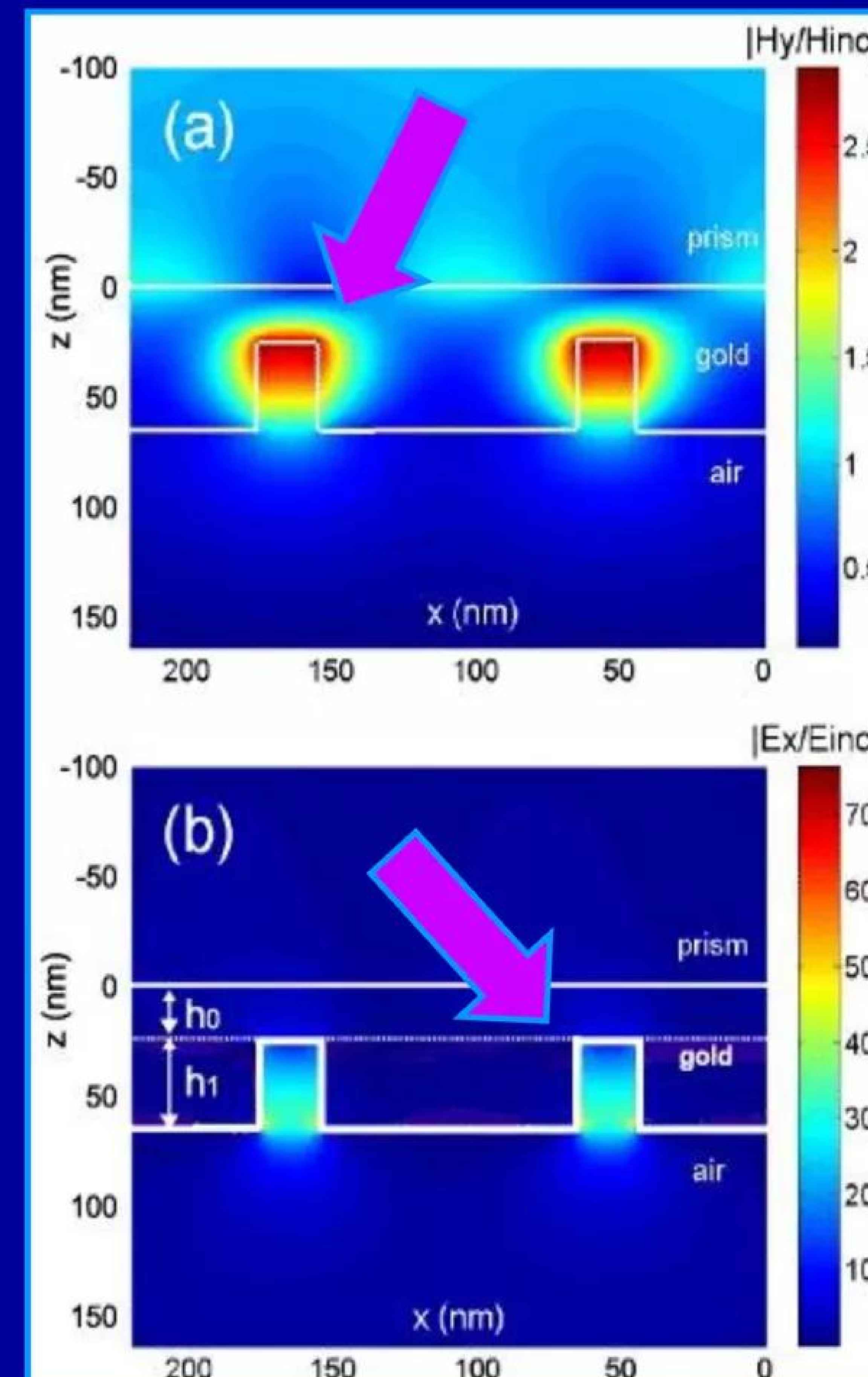
http://spie.org/documents/Newsroom/Imported/003435/003435_10.pdf

Reference:

"Enhancing reactive energy through dark cavity plasmon modes"
J. Le Perchec
***Europhysics Letters* 92 DOI: 10.1209/0295-5075/92/67006 (2010)**

Abstract:

"We present an opto-geometrical configuration in which a metallic surface having nanometer-scale grooves can be forced to efficiently resonate without emitting radiation. The structure is excited from the backside, by an evanescent wave, which allows to inhibit light re-emission and to drastically modify the quality factor of the resonance mode. The energy balance of the system, especially the imaginary part of the complex Poynting vector flux, is theoretically analysed thanks to a modal method. It is shown how the generated hot spots (coherent cavity modes of electro-static type) can store a great amount of unused reactive energy. This behaviour might thus inspire a novel use of such highly sensitive surfaces for chemical sensing."



Credit: J. Le Perchec

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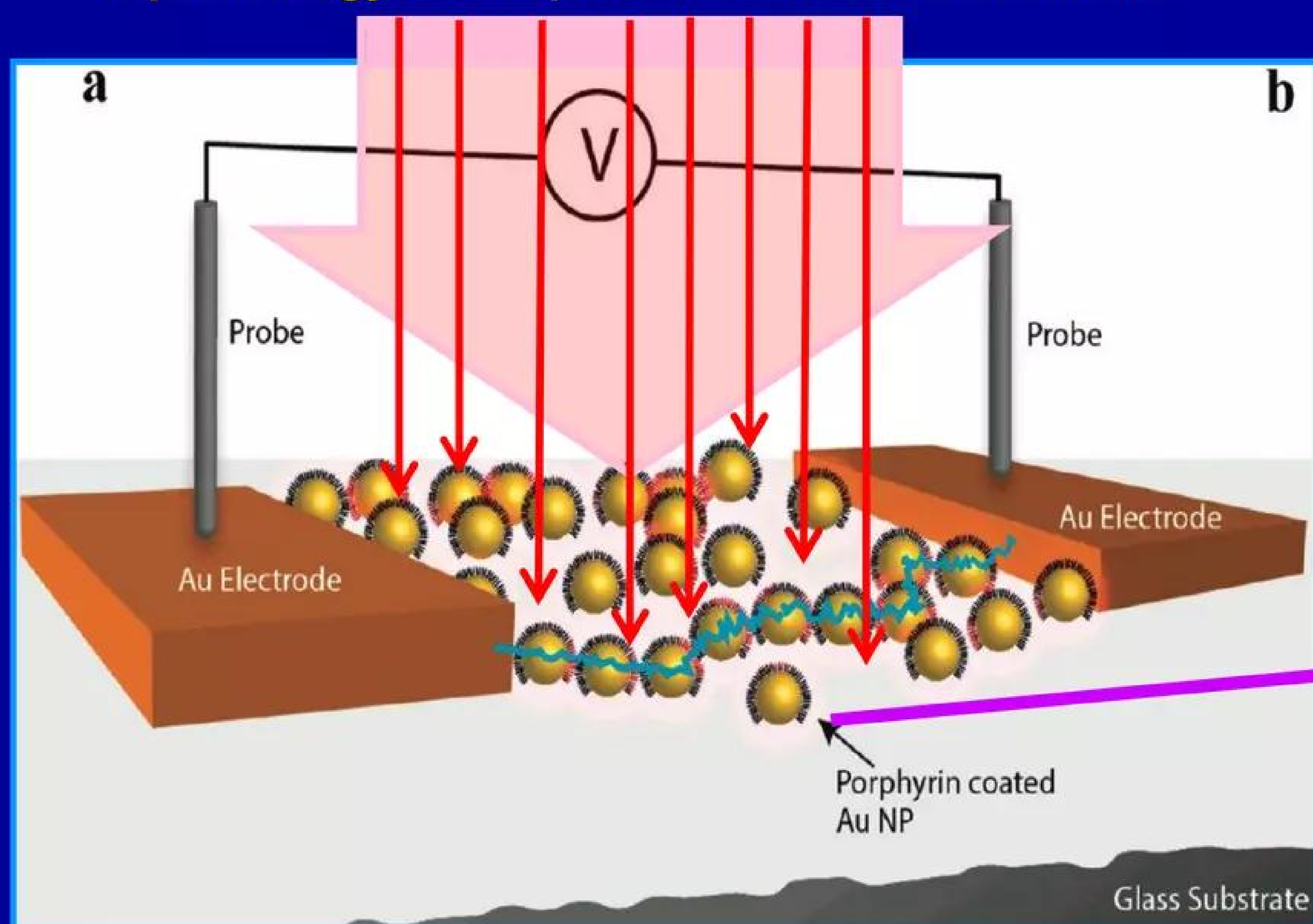
Laser beams input energy into SP and π electrons

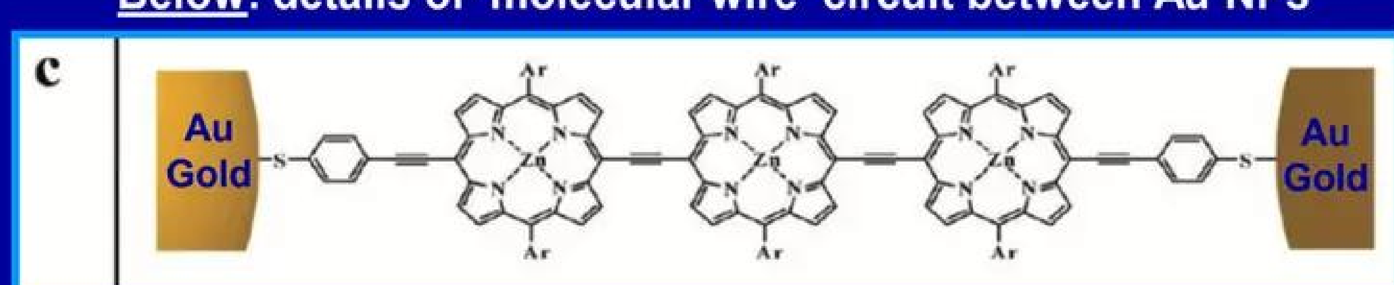
<u>Images and captions adapted from</u>:

"Plasmon-Induced Electrical Conduction in Molecular Devices," P. Banerjee *et al.*
ACS Nano 4 pp. 1019 - 1025 DOI: 10.1021/nn901148m (2010)
http://pubs.acs.org/doi/abs/10.1021/nn901148m

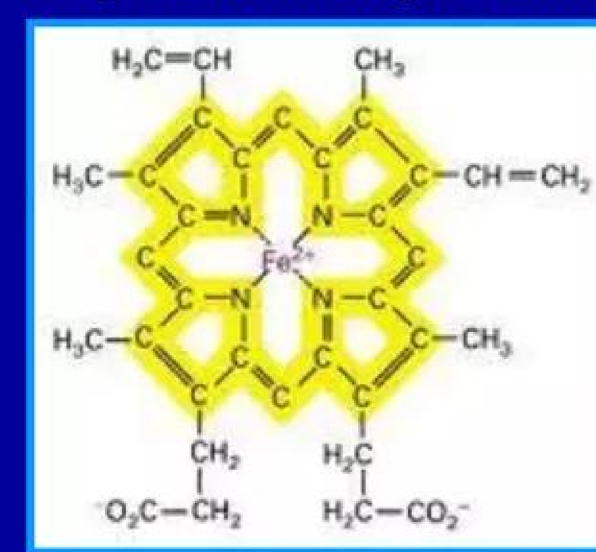
Input energy = E-M photons emitted from laser

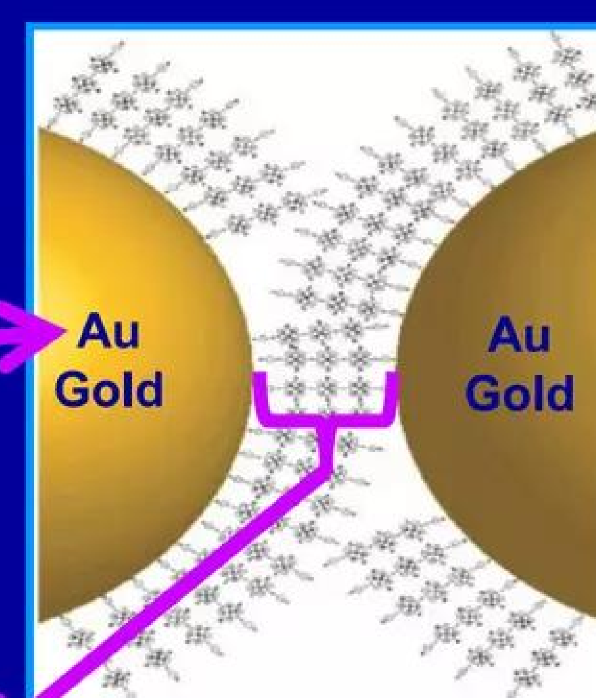


<u>Below</u>: details of 'molecular wire' circuit between Au NPs



Example of Porphyrin Carbon rings coordinating Fe atom





Short chains of linked Porphyrin molecules serve as 'bridge wires' between surfaces of adjacent metallic Au nanoparticles

<u>Quoting directly from their abstract</u>:

"Metal nanoparticles (NPs) respond to electromagnetic waves by creating surface plasmons (SPs), which are localized, collective oscillations of conduction electrons on the NP surface. When interparticle distances are small, SPs generated in neighboring NPs can couple to one another, creating intense fields. The coupled particles can then act as optical antennae capturing and refocusing light between them. Furthermore, a molecule linking such NPs can be affected by these interactions as well. Here, we show that by using an appropriate, highly conjugated multiporphyrin chromophoric wire to couple gold NP arrays, plasmons can be used to control electrical properties. In particular, we demonstrate that the magnitude of the observed photoconductivity of covalently interconnected plasmon-coupled NPs can be tuned independently of the optical characteristics of the molecule - a result that has significant implications for future nanoscale optoelectronic devices."

Free copy of entire paper at http://dukespace.lib.duke.edu/dspace/bitstream/handle/10161/4102/274635800055.pdf?sequence=1

Lattice Energy LLC

Nanotechnology is crucial to commercialization

- ✓ At the present stage of LENR technology (TRL-2), trying to immediately fabricate nm- to cm- scale and larger LENR devices that are supposed to produce macroscopically large fluxes of excess heat and rapidly "*boil a cup of tea*" is really putting the cart before the proverbial horse

- ✓ Unlike its competitors, Lattice plans to use its unique proprietary knowledge of LENR physics, nanotech-based device fabrication strategies, and key operating parameters (e.g., achieving and maintaining very high local surface electric fields) to first get key LENR effects --- such as maximizing $e^- p^+$ area-densities, maximizing ULM neutron production in 'patches', reliably fabricating key nanostructural design features, excess heat production, choice of 'target fuels', 'guiding' of transmutation reaction pathways and products, etc. --- working reliably on microscopic length scales in very small laboratory-grade nanodevices that have intentionally limited numbers of potentially LENR-active surface 'patch' sites

- ✓ That is, to be able to cause LENR effects to occur reproducibly on specific nanoparticulate structures with dimensions ranging from nanometers to microns that are fabricated using existing, off-the-shelf nanotechnology techniques and methods and deliberately emplaced, along with suitable 'target fuel' nuclei (e.g., Lithium atoms) in close proximity, on specific types of purpose-built nanostructures located on loaded metallic hydride surfaces

- ✓ Once these key technical goals have been successfully achieved and LENR processes are working extremely well on nanoscale regions of Lattice's laboratory R&D devices, scaling-up total device-level heat outputs could then be achieved simply by increasing the total number of emplaced LENR-active 'hot spot' sites per cm^2 of effective working surface area

- ✓ Lattice's nanocentric approach to LENR R&D is also unique in that it is highly interdisciplinary, being guided by various aspects of W-L theory and applying relevant knowledge adapted from advanced materials science, plasmonics, and nanotechnology

Lattice Energy LLC

Mapping theory into real-world experiments

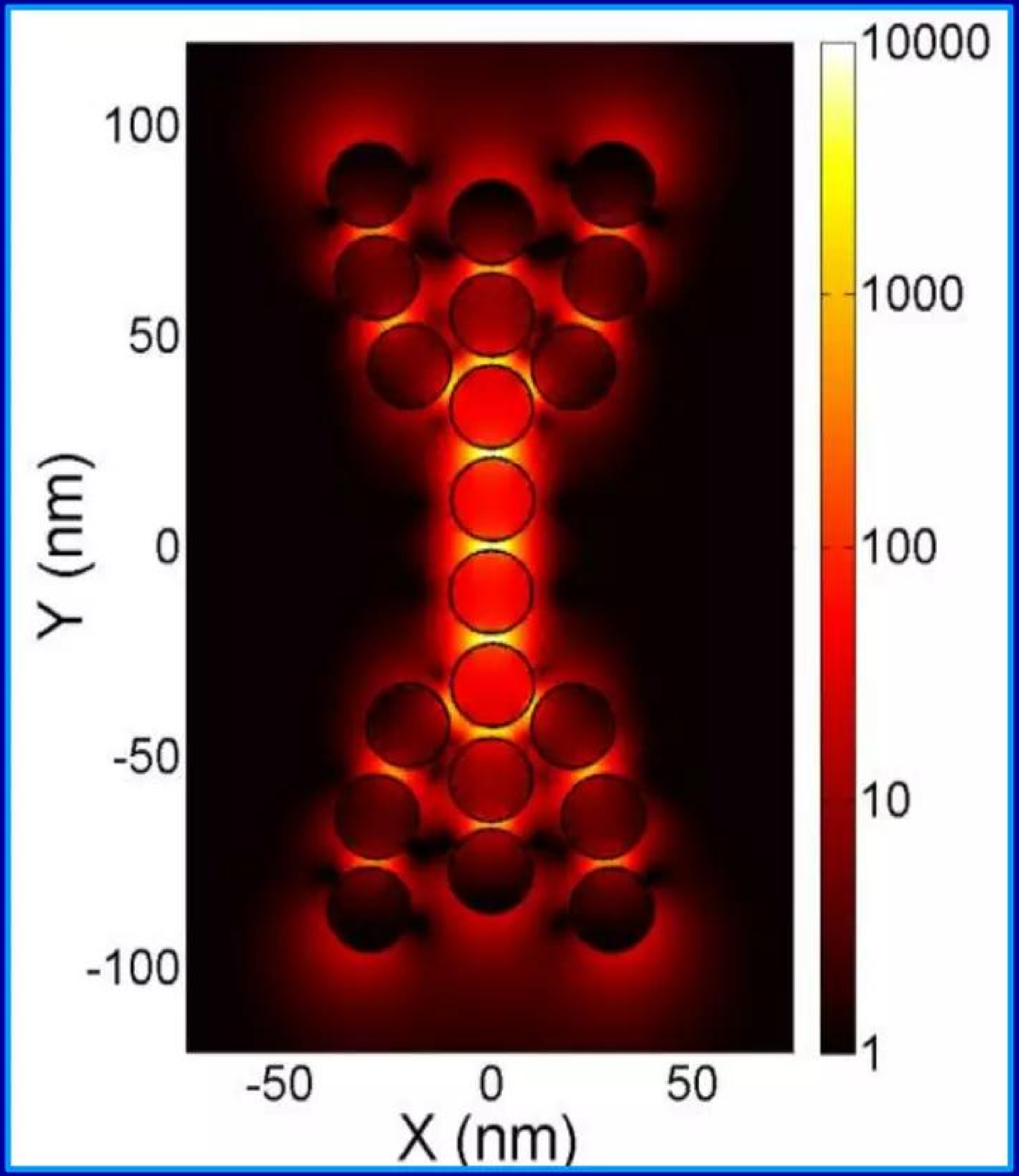


Image credit: Fig. 4 caption, *"Electric field intensity profile for an optimized cluster of 20 nanoparticles"*, in *"Plasmonic hot spots: nanogap enhancement vs. focusing effects from surrounding nanoparticles,"* P. Pavaskar *et al*., *Optics Express* 20 pp. 14656-14662 (2012) at http://www.opticsinfobase.org/oe/fulltext.cfm?uri=oe-20-13-14656&id=238395

Lattice Energy LLC

New Energy Times: index to experimental methods

Electrolysis with low-power laser

Source - html version: http://newenergytimes.com/v2/reports/Index-of-LENR-Experimental-Methodologies.shtml

pdf: http://www.slideshare.net/StevenKrivit/lenr-methodsdistributioncopyrightnewenergytimes20130522-21707257

- ✓ On May 22, 2013, *New Energy Times* published an updated version of a very helpful, *"Index of LENR experimental methodologies,"* that uses simple graphic images and very idealized examples to conceptualize and characterize ~20 different types of experiments conducted in LENR R&D
- ✓ While it is not necessarily totally perfect or all-encompassing, *NET's* index is extremely useful for gaining a rapid appreciation of very different types of LENR experiments that have been conducted and data that was subsequently collected and then published in one venue or another
- ✓ On the next Slide, we will present an idealized method selected from the *NET* Index and map it into new Russian experiments by Barmina *et al.* involving laser ablation of metallic 'targets' (with or without electrolysis) in heavy water (D_2O)

List of LENR Experimental Methods

Source: © *New Energy Times*

Category: Electrolytic Methods

- Electrolysis in heavy water
- Electrolysis in light water
- → **Electrolysis with low-power laser**
- Electrodiffusion with double-structure cathode
- High-voltage plasma electrolysis in D_2O or H_2O
- Electrolytic co-deposition
- Thin-film electrolysis in packed bed
- Thin-film electrolysis on substrate

Category: Gas Methods

- Gas loading on bulk metal (rod or wire)
- Gas absorption into metal nano-powder
- Gas plasma - glow discharge
- Gas permeation through thin-films
- Gas permeation through thin metals

Category: Unique Methods -

- Exploding wires
- Electron beam impact
- Sonic implantation
- Biological processes
- Electromigration through solid-state proton conductors
- Carbon arc experiments
- Hydrogen loading of Phenanthrene

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New Energy Times: index to experimental methods

Electrical current and/or laser provide input energy to produce neutrons

Idealized method: electrolysis with low power laser

Method discovered by Letts & Cravens (USA) *ca.* 2002 - 2003

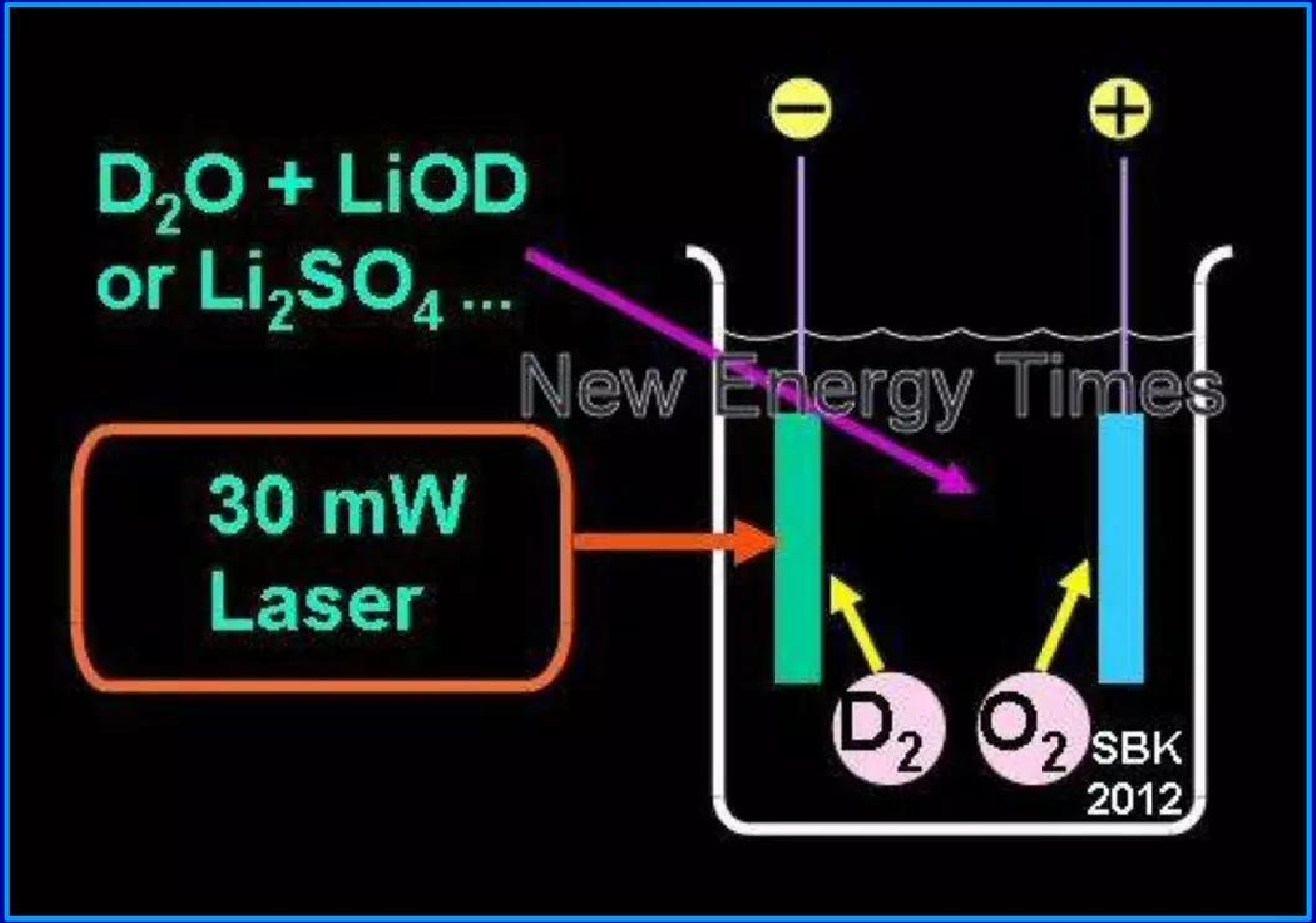

Image credit: *New Energy Times*

Lattice Energy LLC

Letts & Cravens, USA (ICCF-10, 2003)

Reference: provided earlier in this document

Key highlights of their laboratory experiments:

- ✓ Used D_2O in Pons & Fleischmann-type aqueous electrolytic cell; 1M LiOD with planar Palladium (Pd) cathode; Platinum (Pt) coil anode; rigged-up secondary Gold (Au) anode that co-deposited Au along with Deuterium ions onto the Pd cathode. Excess heat production during the experiments was measured in parallel via integrated calorimetry, a technique with which Letts & Cravens were extremely experienced
- ✓ After a period of Au co-deposition and Deuterium 'loading' of the specially prepared cathode, low-power tunable laser was shined through intervening materials onto cathode's planar Au/Pd working surface
- ✓ Measured increases in laser-triggered excess heat production; some were substantial multiples of total laser input power; in their paper, see Figure 11B and caption: in Cathode #602 measured >10x multiple
- ✓ Concluded that: input energy contained in incident laser beams can directly trigger LENRs on cathodes in electrolytic cells; this triggering effect has since been independently confirmed by other researchers

Lattice comments on their experimental results:

- ✓ See their 2003 ICCF-10 presentation for additional experimental details, including cathode preparation
- ✓ Letts & Cravens apparently first researchers in field to observe laser triggering of LENR heat production
- ✓ Upon first hearing about these laser triggering results, Larsen and Violante independently realized that decisive role of Gold overlayer in these new experiments strongly suggested that surface plasmons (SP) likely play key role in LENR processes, certainly in cases of aqueous D_2O and also H_2O electrolytic cells
- ✓ Pursuing Mizuno's speculative conjecture (his book, 1998), Larsen had already been working since 1999 to develop a rigorous neutron-catalyzed theory of LENRs starting with electroweak neutron production via $e+p \rightarrow n$, $e+d \rightarrow 2n$ or $e+t \rightarrow 3n$ reactions; data implied SP electrons were involved, not K-shell captures

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Violante *et al.*, ENEA, Italy (ICCF-10, 2003)

Reference: "*Analysis of Ni-hydride thin film after surface plasmons generation by laser technique,*" V. Violante *et al*., in *Condensed Matter Nuclear Science - Proceedings of the 10th International Conference eon Cold Fusion* (ICCF-10 2003), P. Hagelstein and S. Chubb, eds.
World Scientific; Singapore ISBN# 981-256-564-7 pp. 421 - 434 (2006)
http://www.lenr-canr.org/acrobat/ViolanteVanalysisof.pdf

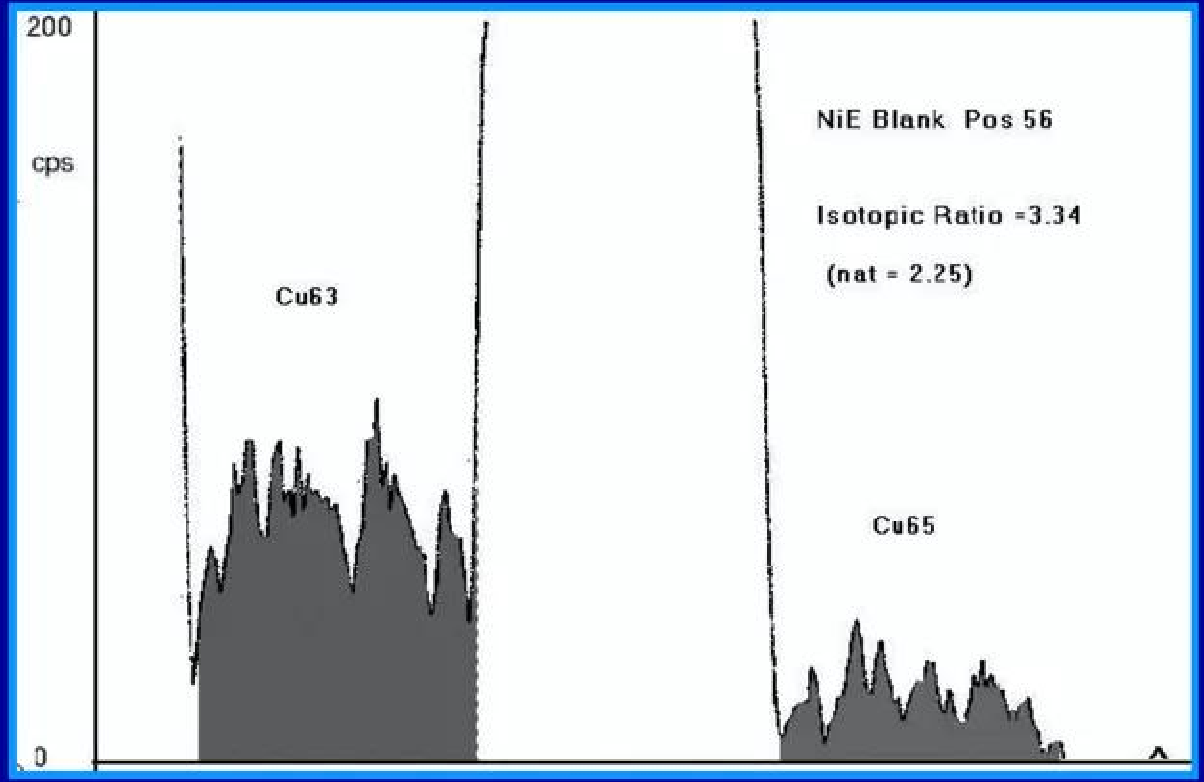
Key highlights of the experiment:

- ✓ Fabricated two sputtered thin-film pure Nickel 'target' samples; "*black*" sample was loaded with hydrogen (made NiH) in electrolytic cell; "*blank*" sample was not put into electrolytic cell (not H-loaded)
- ✓ Aqueous H_2O 1 M Li_2SO_4 P&F-type electrolytic cell; thin-film Nickel (Ni) cathode; [Platinum pt anode?]; loaded "*black*" Ni 'target' cathode with Hydrogen for 40 minutes at currents ranging from 10-30 mA and then removed cathode from the aqueous electrolyte bath
- ✓ Irradiated both samples with He-Ne laser (632 nm beam) for 3 hours
- ✓ After laser irradiation, analyzed Cu isotopes present on surface in "*blank*" and "*black*" Ni samples with SIMS; results shown in Figs. 12 and 13 to right: abundance of ^{63}Cu went down; ^{65}Cu went way up
- ✓ Suggested surface plasmons might have important role in LENRs

Comments: observed dramatic isotopic shift (^{63}Cu goes down; ^{65}Cu goes up in an experiment) that is readily explained by ULM neutron capture on ^{63}Cu 'seed' according to W-L theory of LENRs; if data is correct, only other possible explanation is magically efficient isotopic "*fractionation*" process

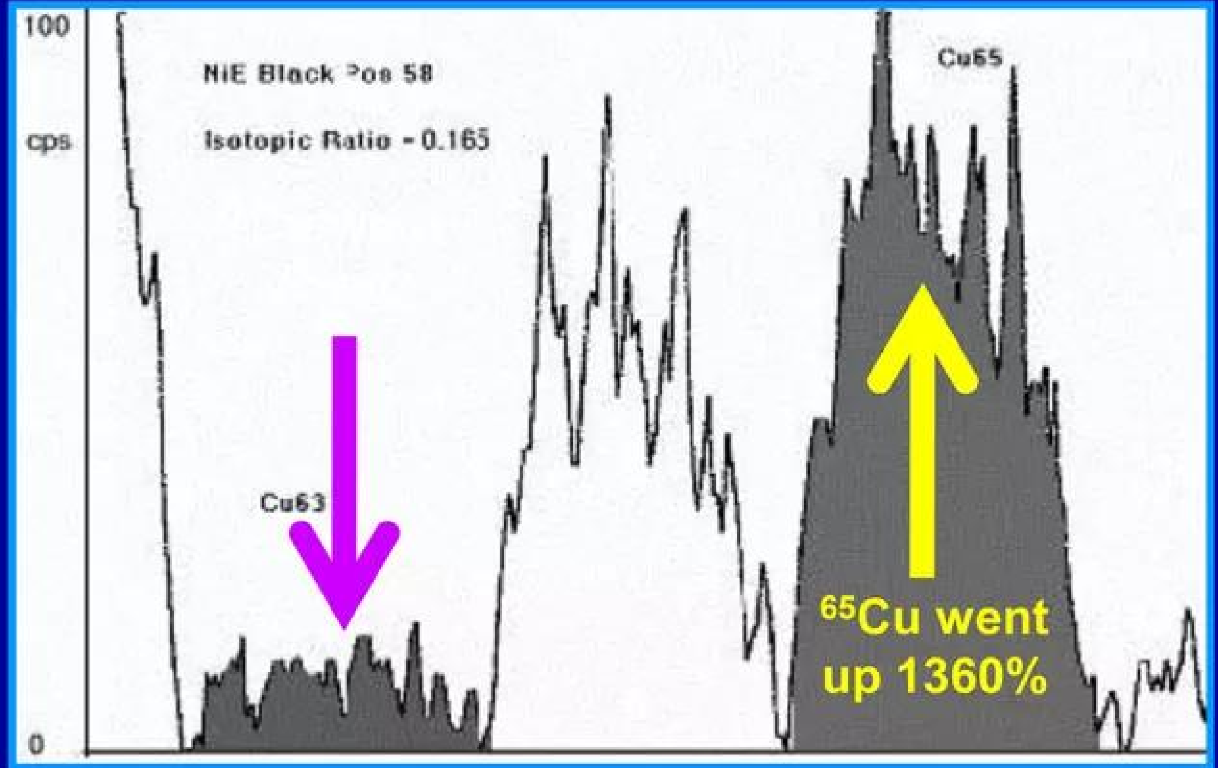
Note: we have been informed that Violante *et al.* have recently questioned their own claims *ex post facto* for reasons we deem *very* dubious. Readers are urged to review relevant publications to judge whether such revisionism is plausible

BEFORE: Cu isotopes present in "*blank*" Ni sample



Quoting: "Figure 12. Blank of NiE, ^{63}Cu results to be more abundant of ^{65}Cu, the difference with the natural isotopic ratio is due to the small signal on mass 65. The sample was undergone to laser excitation of plasmons-polaritons for 3 hr."

AFTER: Cu isotopes present in "*black*" NiH sample



Quoting: "Figure 13. Black of NiE, after 40 min electrolysis + 3 hr of plasmons-polaritons excitation by laser. Isotopic ratio is changed of 1360%"

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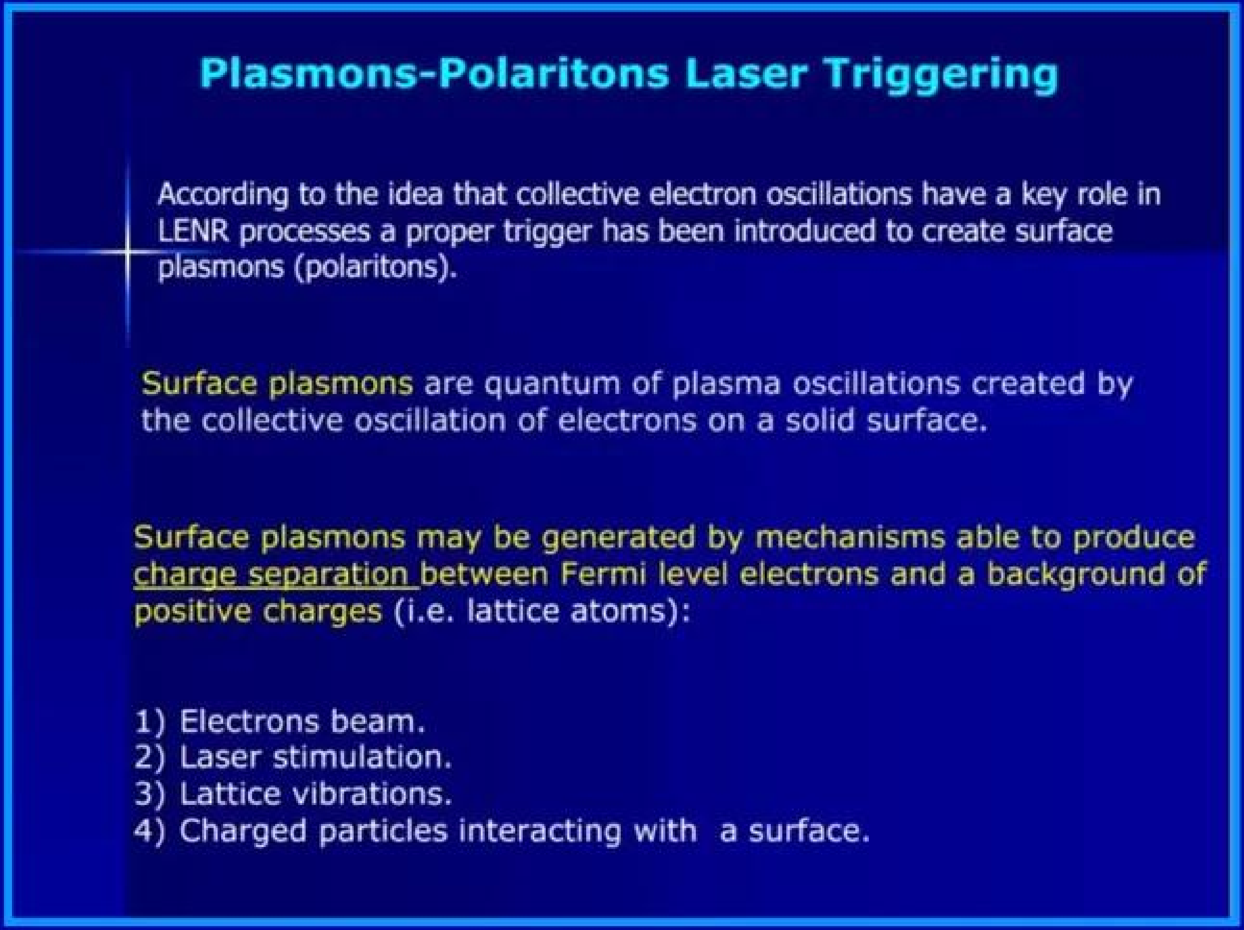
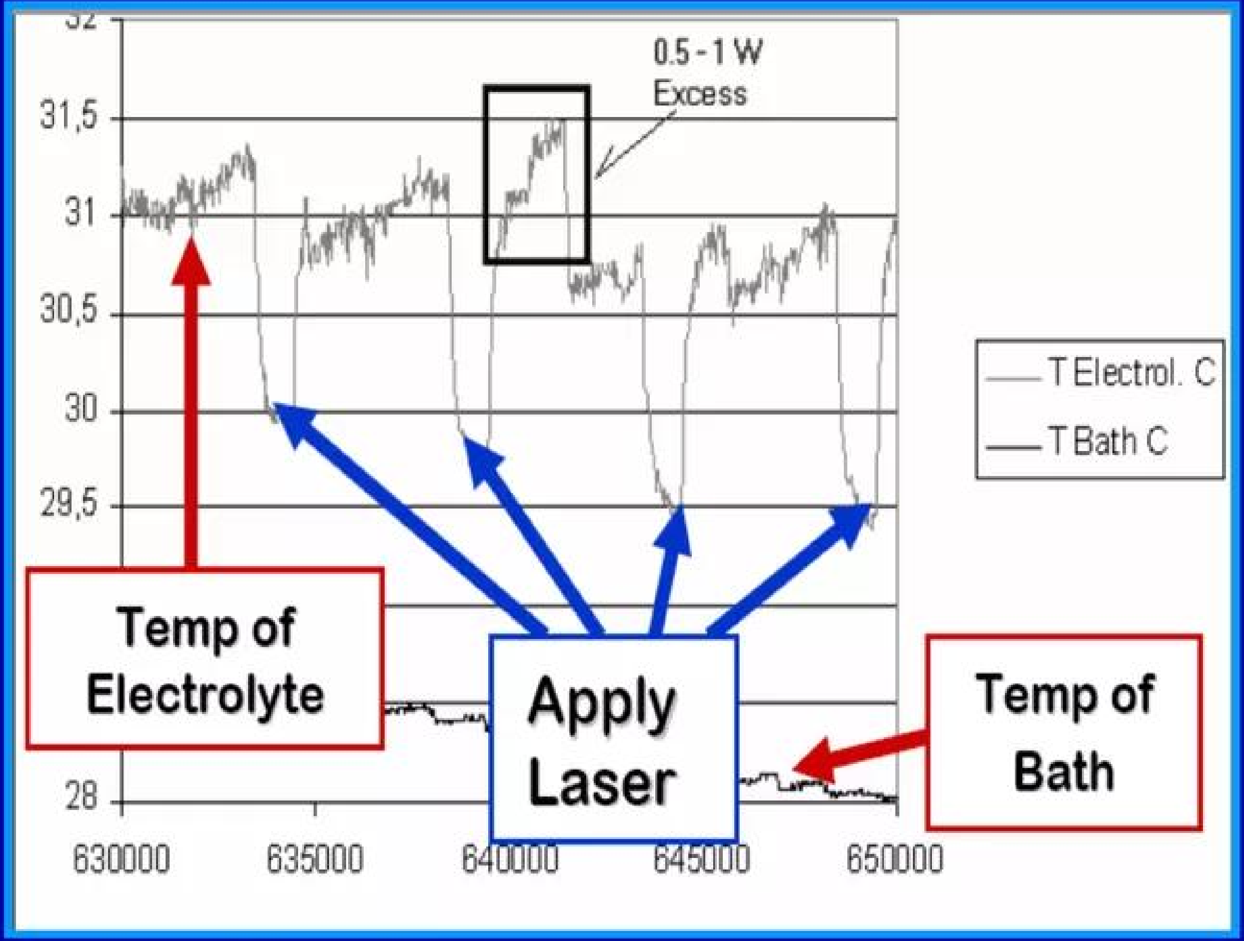
Violante *et al*., ENEA (Asti & ICCF-11, 2004)

- ✓ Independently confirmed laser triggering of LENRs that had first been reported by Letts & Cravens at ICCF-10 in 2003
- ✓ Connected laser triggering to absorption of photon energy by surface plasmon electrons on surface of Au-coated Pd 'targets'
- ✓ Conducted laser light polarization experiment that 'clinched' involvement of surface plasmons in anomalous excess heat produced by LENRs in condensed matter D_2O electrolytic cells
- ✓ In ICCF-11 presentation, using mass spectroscopy, claimed to have observed production of Helium-3 and Helium-4 after laser triggering and in conjunction with production of excess heat
- ✓ "*Review of Recent Work at ENEA*"
  M. Apicella *et al*. [39 slides - on first slide of PowerPoint presentation, V. Violante of ENEA-Frascati listed as coauthor] ICCF-11, Marseilles, France Oct. 31 - Nov. 5, 2004
  http://newenergytimes.com/v2/conferences/2004/ICCF11/pres/64-Violante.pdf

Lattice comment: inexplicably, the text and data found in this presentation about experimental work, including that on laser triggering of LENRs by ENEA researchers, were mysteriously omitted from any inclusion in official *Proceedings* of this conference that were edited by J-P. Biberian (France) and then published by World Scientific in 2006 [ISBN 981-256-640-6]



Slide #20 in ENEA presentation at ICCF-11 (2004)



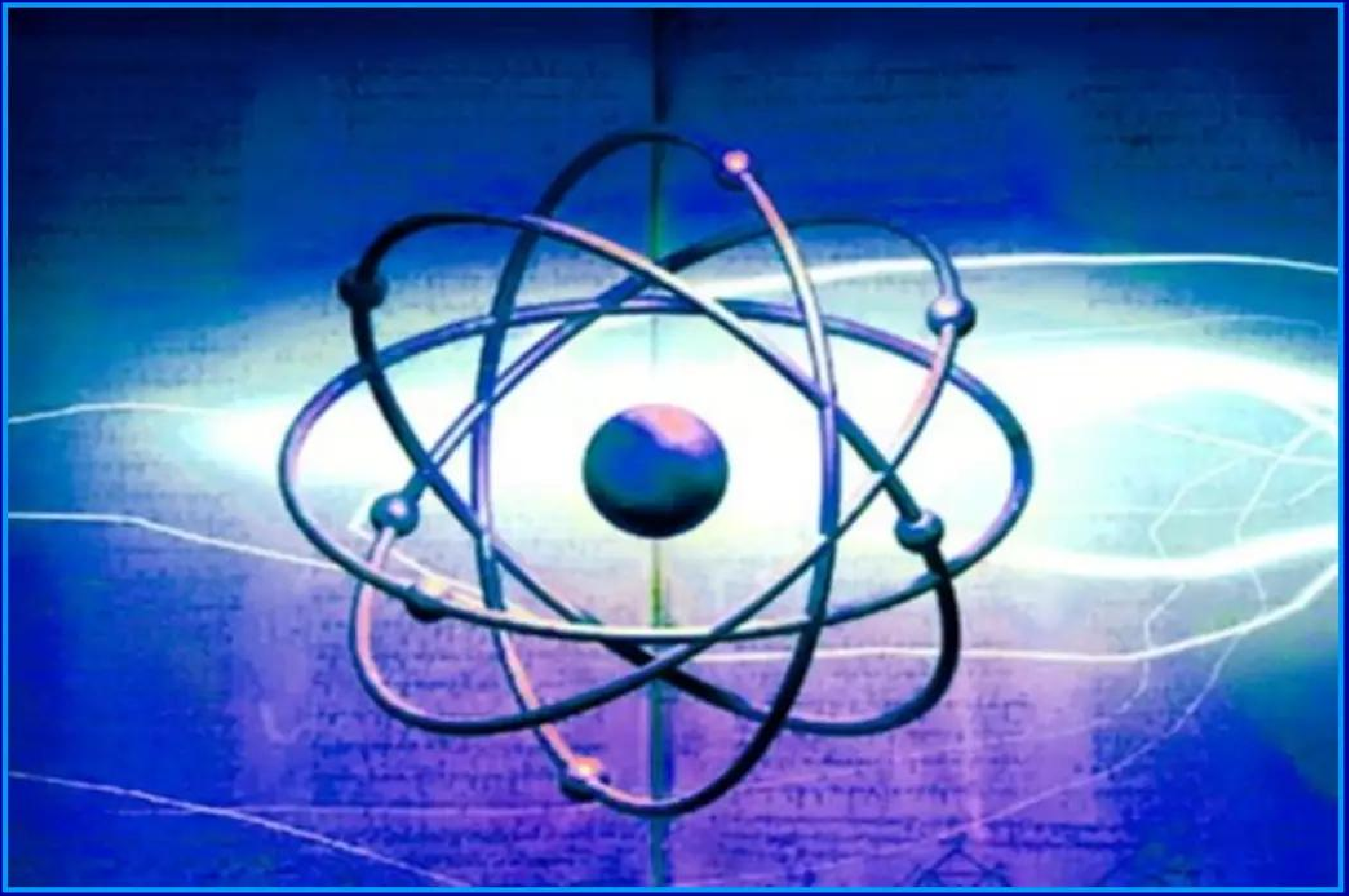
Adapted from Violante's ENEA presentation at Asti LENR workshop (Italy, 2004)

Lattice Energy LLC

Commercializing a Next-Generation Source of Green Nuclear Energy

Discussion of Barmina *et al.'s*

arXiv:1306.0830v1 June 3, 2013



"It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to suit facts."

Sherlock Holmes, "*A Scandal in Bohemia*" (1891)

Lattice Energy LLC

Barmina *et al*. (Russia, arXiv 2013)

Claimed to have observed production of Tritium and decay rate changes

Reference: provided earlier in this document

Key highlights of their laboratory experiments and reported data:

- ✓ Type #1 (Table 1. control + two experiments): irradiated and ablated Gold (Au) and Titanium (Ti) bulk 'targets' immersed in a glass cell containing pure liquid D_2O with pulsed, high-power laser beams at wavelengths of 1064 nm; at start of experiments, NO Tritium above background levels could be detected in D_2O. RESULTS: measured and reported detectable production as well as destruction (they call it "*accelerated decay*") of significant quantities of radioactive Tritium ($_1H^3$ or t^+) during these laser-input-energy experiments with targets

- ✓ Type #2 (Table 1. two experiments): conducted other closely-related experiments involving electric-current-driven electrolytic cells: in these experiments, Au and Ti 'targets' of same composition as in Type #1 served as cathodes with the anodes consisting of either stainless steel or Platinum wires, all being immersed in an NaOD electrolyte. Cathodes were Hydrogen-loaded with an electric current (very much like in a 'classic' Pons & Fleischmann $Pd_{cathode}/Pt_{anode}$ LiOD electrolytic LENR cell) while simultaneously undergoing irradiation and ablation by 532 nm wavelength laser beams. RESULTS: observed vastly larger amounts of Tritium production (10^3x increase vs. only~18x increase) compared otherwise somewhat similar Type # 1 experiments at 1064 nm laser irradiation *without* simultaneous electrolysis. (Expt. #4 in Table 1. with bulk Titanium very interesting; although ~50% lower wavelength, had 10^2 lower intensity and 30% less irradiation time)

Lattice Energy LLC

Barmina *et al*. (Russia, arXiv 2013)

Claimed to have observed production of Tritium and decay rate changes

Key highlights of their laboratory experiments and reported data (continued):

- ✓ Type #3 (Table 2. control + four experiments): almost the same as Type #1 (including no electrolysis), except that in this case there is some detectable Tritium initially present in the D_2O at the start of experiments and bulk targets used were instead Selenium (Se) and Gold (Au); irradiation was at 510 nm and at 532 nm for each target. RESULTS: at 532 nm generally observed vastly lower Tritium production in comparison to Type #2 with electrolysis; irradiation at more energetic 510 nm was significantly less effective at producing Tritium than ~comparable amounts of irradiation at 532 nm. (Expt. #2 in Table 2. with a bulk Se target is also interesting: Tritium activity actually *decreased* by factor of 6.7)

- ✓ Type #4 (Table 3. control + five experiments): in the last group of experiments, they irradiated and ablated Au, Ti, and Pd bulk targets at 532 and 1064 nm in parallel with electrolysis in NAOD electrolyte that *by design had initial above-background Tritium activity of* 1.22×10^{-3} *Ci/l*. RESULTS: data collected in these 5 experiments was in some ways quite surprising; instead of *increasing* the measured levels of Tritium activity above and beyond the initial starting value of 1.22×10^{-3} *C/l* (as one might naively expect given the results of their Type #2 experiments, some of which showed Tritium activity increases on order of 10^3 x), measured Tritium activity either stayed ~the same or *went down* in all five of these Type #4 experiments. To explain this anomaly in experiments with "*relatively high DOT content*," they conjectured that this behavior was evidence for "*laser-induced decay of Tritium*" i.e., Tritium's decay rate was being changed by laser irradiation and ablation

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Barmina *et al*. (Russia, arXiv 2013)

Key highlights of their laboratory experiments and reported data (continued):

Lattice comments:

This direct comparison of data extracted from Tables 1. and 3. in Barmina *et al.* illustrates the observed anomaly very well. Note that Type #2 and Type #4 experiments only substantively differ in the respect that Type #2 essentially starts with no Tritium activity above background levels (8.64 x 10^{-8} *Ci/l*), whereas Type #4 starts with 1.22 X 10^{-3} *Ci/l*. Assuming these data are measured properly and accurately, the Type #4 experiments exhibit unexpected, anomalous slight decreases in Tritium activity during irradiation

Table 1. Type #2 - copied from paper; experiments with electrolysis

№	Material	Kind of liquid	Wavelength of laser beam, nm	Intensity of laser radiation, W/cm² and pulse width	Time of irradiation, min	Electrolysis	Activity, Ci/l (In control was 8.64 x 10^{-8} ($\mathcal{E}$=3.54 x 10^{-14}))	Change with respect to initial level
2	Au	NaOD	532	5×10^{11} 10 ps	60	+	4.06×10^{-4} $\xi=1.66\cdot10^{-10}$	Increase 4.7×10^{3}
4	Ti	NaOD	532	10^{11}	62	+	4.74×10^{-4} $\xi=1.94\cdot10^{-10}$	Increase 5.5×10^{3}

Table 3. Type #4 - copied from paper; experiments with electrolysis

No	Material	Kind of liquid	Wavelength of laser beam, nm	Intensity of laser radiation, W/cm²	Time of irradiation, min	Activity, Ci/l (In control was 1.22 x 10^{-3} ($\mathcal{E}$ = 0.5 x 10^{-9}))
2	Au	NaOD	532	10^{11}	61	1.12×10^{-3}
4	Ti	NaOD	532	10^{11}	60	1.11×10^{-3}

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Barmina *et al*. (Russia, arXiv 2013)

Conjecture new states of nuclear matter, dineutrons, and "e-catalysis"

Invent their own 'new nuclear physics' to explain reported data

Summary of their proposed theoretical explanation for experimental results:

Note: only sketchy details about Barmina *et al.*'s new theoretical ideas (which in certain ways differ significantly from presently well-accepted concepts in nuclear physics) that they claim are able to explain their experimental data are presented in v1 of the June 3, 2013, arXiv preprint. Instead, those ideas are explained in two different, relatively new theoretical papers cited in the arXiv preprint as follows:

- ✓ **"*Nuclear processes initiated by electrons*"**
  S. Timashev, V. Muromtsev, and A. Akovantseva
  ***Russian Journal of Physical Chemistry A* 87 pp. 1063 - 1069 (2013)**

- ✓ ***"Beta-dineutron as a radioactive element and its possible role in nuclear synthesis processes"***
  S. Timashev
  "In press" as of June 3, 2013

Barmina *et al.* rely on these new publications to support their theoretical speculation.

Lattice Energy LLC

Barmina *et al*. (Russia, arXiv 2013)

Conjecture new states of nuclear matter, dineutrons, and "e-catalysis"

Invent their own 'new nuclear physics' to explain reported data

Summary of their proposed theoretical explanation for experimental results:

- ✓ **arXiv:1306.0830v1 pp. 6 - 7: Barmina *et al*. make special note that they believe that very high local electric fields at 'pointy' asperities and on the surfaces of nanostructures produced during electrolysis and/or laser ablation of bulk targets are very important for triggering nuclear transmutation processes that are occurring during their experiments**
- ✓ **arXiv:1306.0830v1 pp. 8 (paragraph 2): right here, they go on describe a so-called "*electron-nucleus interaction*" with a Deuteron (d^+) that results in the creation of a "*virtual neutron*" and the "*… emission of a neutrino*." [Lattice comment: this passage clearly describes the e^- + d^+ electroweak reaction in the Widom-Larsen theory, with the difference being that W-L theory posits *real* neutrons, a key conjecture which is well-supported by abundant experimental data that we cite in our various publications]**
- ✓ **arXiv:1306.0830v1 pp. 8 - 9: herein, Barmina *et al*. make garbled statements about the energetics of such an electroweak e^- + d^+ reaction; they apparently were unsure as to how to create near-MeV electron energies required to make-up the mass-deficit and create neutrons in condensed matter under 'mild' conditions. To solve that problem, they conjured-up a new "*non-standard, non-balanced or inner shake-up state of nuclear matter*." [Comment: W-L solves this issue with many-body collective quantum effects]**

Lattice Energy LLC

Barmina *et al*. (Russia, arXiv 2013)

Conjecture new states of nuclear matter, dineutrons, and "e-catalysis"

Invent their own 'new nuclear physics' to explain reported data

Summary of their proposed theoretical explanation for experimental results:

- ✓ **arXiv:1306.0830v1 pp. 9 (paragraph 1): Barmina *et al.* now conjecture two *new* types of bound, multi-neutron particles, the so-called "*β-dineutron* ($^{2}n_{isu}$)" and the "*β-trineutron* ($^{3}n_{isu}$)." They claim that these neutral 'catalytic' particles are created in their theorized "*in-shake-u*p" (theorized) nuclear state involving electrons and nuclei, e.g., p^+, d^+, or t^+. They freely acknowledge that, "*… electrons* [only] *having kinetic energy E_e ~ 5 - 10 eV* [are present] *in cold plasma,*" yet in their preprint they don't provide any hints about detailed physics or rigorous calculations that could show why their hazy theoretical construct for electroweak neutron production via a so-called "*in-shake-up*" state is remotely plausible. [Lattice comment: dineutron decay was first-reported last year, "*First observation of ground state dineutron decay:^{16}Be*," A. Spyrou *et al*., *Phys. Rev. Lett.* 108 pp. 102501 (2012). In a personal communication with A. Spyrou on 6/12/2013, Artemis Spyrou stated they didn't measure dineutron's half-life; she believes $t_{½}$ is probably ≤ 10^{-21} to 10^{-22} sec.**

- ✓ **arXiv:1306.0830v1 pp. 9 (paragraph 2): herein, Barmina *et al*. show a Triton t^+ reacting with an electron - "*e-catalysis*" *accelerated decay* - [electroweak *e* + *t* reaction in W-L theory] to create their theorized bound "*β*-trineutron" particle which then beta-decays into a Helium $_2He^3$ 2^+ion, beta particles, and antineutrinos. [No mention made of possibility that "*β*-trineutrons" might be captured by other atoms on surfaces of targets]**

Lattice Energy LLC

Barmina *et al*. (Russia, arXiv 2013)

Proposed explanation for production and destruction of Tritium

Summary of proposed reactions that they believe account for their observed results:

Note: Barmina *et al*. state that "he" subscript on electrons e^-_{he} indicates the, "… initiative character of interaction between the electron and the deuteron in the formation of the β^- dineutron $^2n_{isu}$ in the in-shake-up state."

Production of neutrons (n):

$$e^-_{he} + d^+ \rightarrow {}^2n_{isu} + \tilde{\nu} \quad (1)$$

Note: Barmina *et al*. state that "*isu*" subscript on the 'bound' dineutron $^2n_{isu}$ indicates that it is in their theorized, "… in-shake-up state," which they describe as a, "… non-standard, 'non-balanced' or 'inner shake up' ('in-shake-up') state of nuclear matter" [whatever that means?]

Production of Tritium (t^+):

$$d^+ + {}^2n_{isu} \rightarrow t^+ + n + Q(3.25 MeV) \quad (3)$$

So-called "*e-catalysis*" and "*accelerated decay,*" i.e. destruction, of Tritium (t^+):

$$t^+ + e^- \rightarrow {}^3_0n_{isu} + \nu \rightarrow {}^3_2He^{2+} + 2e^- + \nu + 2\tilde{\nu} + Q(0.019 MeV) \quad (4)$$

On pp. 9 in preprint, Barmina *et al*. state that (quoting), "All experimental results presented above can be interpreted on the basis of the processes (1), (3), and (4) … decay of Tritium is a competing process that determines the stationary level of Tritium during laser exposure."

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Barmina *et al*. (Russia, arXiv 2013)

Lattice discussion of their experimental results, data, and proposed explanation:

- ✓ **Widom-Larsen theory (2006) suggests that electric currents and laser irradiation can be used *in combination* to provide input energy that is used to drive neutron production via many-body collective electroweak reactions**

- ✓ **This prediction is consistent with Barmina *et al.*'s reported experimental results: Type #2 experiments that <u>added</u> electrolysis to laser irradiation of bulk targets generally produced substantially higher levels of Tritium activity. This differential result would be expected according to W-L because, all other things being equal, the more usable input energy that is provided to drive electroweak neutron production, the larger the ultra low momentum neutron fluxes, and the larger the resulting Tritium production arising from ULM neutron captures on Deuterium present as a reactant**

W-L theory: input of laser energy enhances LENR neutron production

> the case of deuterium. (iii) However, one seeks to have either nearly pure proton or nearly pure deuterium systems, since only the isotopically pure systems will easily support the required coherent collective oscillations. (iv) An enforced chemical potential difference or pressure difference across a palladium surface will pack the surface layer to a single compact layer allowing for the required coherent electric field producing motions. (v) The proton electric field producing oscillations can be amplified by inducing an enhancement in the weakly coupled electronic surface plasma modes. Thus, appropriate frequencies of laser light incident on a palladium surface launching surface plasma waves can enhance the production of catalytic neutrons. (vi) The captured electron is removed from the collective surface plasma oscillation creating a large density of final states for the weak interactions. Most of the heat of reaction is to be found in these surface electronic modes. (vii) The neutrons themselves are produced at very low momenta, or equivalently, with very long wavelengths. Such neutrons exhibit very large absorption cross-sections that are inversely proportional to neutron velocity. Very few such neutrons will escape the immediate vicinity. These will rarely be experimentally detected. In this regard, ultra low momentum neutrons may produce "neutron rich" nuclei in substantial quantities. These neutrons can yield interesting reaction sequences [19, 20]. Other examples are discussed below in the concluding section.

Widom-Larsen theory: on pp. 4 in W & L's *EPJC* paper (2006)

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Barmina *et al*. (Russia, arXiv 2013)

Lattice discussion of their experimental results, data, and proposed explanation:

- ✓ **Widom-Larsen (2006): see eq. (28), (29), and text to right**
- ✓ **Clearly, this prior published thinking of Widom-Larsen also applies to Barmina *et al*.'s experimental system**
- ✓ **Outside of the fact that Letts & Cravens (2003) and Violante *et al*. (2003 - 2004) used much lower-power laser irradiation beams, their much earlier experiments of ~ a decade ago are otherwise very similar to those of Barmina *et al*. (2013), who did not cite any of that previously published work with laser-triggered LENRs**
- ✓ **Barmina *et al*. seem to be aware of key energetics issues surrounding realization of electroweak neutron production in non-star-like condensed matter but unlike W-L, they didn't understand exactly how to utilize the physics and mathematics of many-body collective effects to overcome such issues; hence their *ad hoc* invocation of new theorized "*in-shake-up*" nuclear state**

W-L theory: mass increase sufficient for $e^{*-} + p^{+}$ and $e^{*-} + d^{+}$ reactions

From (16), (19), (25) and (26) follows the electron mass enhancement

$$\beta \approx 20.6 \quad \text{(palladium hydride surface)}\,. \qquad (27)$$

The threshold criteria derived from (6) is satisfied. On palladium, surface protons can capture a heavy electron producing an ultra low momentum neutron plus a neutrino; i.e.

$$(e^{-}p^{+}) \equiv H \rightarrow n + \nu_e\,. \qquad (28)$$

Several comments are worthy of note: (i) The collective proton motions for a completed hydrogen monolayer on the palladium surface require a loose coupling between electronic surface plasma modes and the proton oscillation modes. The often assumed Born–Oppenheimer approximation is thereby violated. This is in fact the usual situation for surface electronic states, as has been recently discussed. It is not possible for electrons to follow the nuclear vibrations on surfaces very well, since the surface geometry precludes the usual very short Coulomb screening lengths. (ii) The above arguments can be extended to heavy hydrogen $(e^{-}p^{+}n) \equiv (e^{-}d^{+}) \equiv D$, wherein the neutron producing heavy electron capture has the threshold electron mass enhancement

$$\frac{\tilde{M}'_e}{M_e} = \beta'(D \rightarrow n + n + \nu_e) > 6.88\,. \qquad (29)$$

(29) also holds true. The value of β in (27) is similar in magnitude for both the proton and the deuterium oscillation cases at hand. Since each deuterium electron capture yields two ultra low momentum neutrons, the nuclear catalytic reactions are somewhat more efficient for

Widom and Larsen: on pp. 3 in *EPJC* paper (2006)

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Barmina *et al*. (Russia, arXiv 2013)

Lattice discussion of their experimental results, data, and proposed explanation:

- ✓ **Widom-Larsen theory (2006): see highlighted section (iii) to the right; because their masses differ greatly, substantial admixtures of different hydrogen isotopes will destroy quantum mechanical coherence in the many-body, collectively oscillating surface 'patches' of protons, deuterons or tritons that according to W-L theory are required to successfully produce ULM neutrons at substantial rates in condensed matter systems at moderate temps**

- ✓ **This Q-M coherence requirement of W-L explains an anomaly in Barmina *et al.*'s reported results we noted earlier: their Type #4 experiments exhibited unexpected, anomalous slight *decreases* in Tritium activity during irradiation and electrolysis, rather than increasing significantly. *Per Widom-Larsen theory, this was not unexpected.* What most likely happened was that when Tritium concentrations were ~0 at the start of experiments, very few Tritium atoms were present in many-body 'patches' at LENR-active sites. Consequently, vast majority of usable input energy went into making neutrons from Deuterium that were captured locally by atoms; captures on abundant D produced Tritium, which increased. By contrast, experiments starting with significant initial Tritium concentrations inadvertently created a situation that enabled formation of some many-body 'patches that were mostly Tritons, which could then support Q-M coherence and t^+ conversion into neutrons, which were captured. Evidently, these two competing processes involving Tritium were ~balanced in Type #4 experiments**

W-L theory: input of laser energy enhances LENR neutron production

the case of deuterium. (iii) However, one seeks to have either nearly pure proton or nearly pure deuterium systems, since only the isotopically pure systems will easily support the required coherent collective oscillations. (iv) An enforced chemical potential difference or pressure difference across a palladium surface will pack the surface layer to a single compact layer allowing for the required coherent electric field producing motions. (v) The proton electric field producing oscillations can be amplified by inducing an enhancement in the weakly coupled electronic surface plasma modes. Thus, appropriate frequencies of laser light incident on a palladium surface launching surface plasma waves can enhance the production of catalytic neutrons. (vi) The captured electron is removed from the collective surface plasma oscillation creating a large density of final states for the weak interactions. Most of the heat of reaction is to be found in these surface electronic modes. (vii) The neutrons themselves are produced at very low momenta, or equivalently, with very long wavelengths. Such neutrons exhibit very large absorption cross-sections that are inversely proportional to neutron velocity. Very few such neutrons will escape the immediate vicinity. These will rarely be experimentally detected. In this regard, ultra low momentum neutrons may produce "neutron rich" nuclei in substantial quantities. These neutrons can yield interesting reaction sequences [19, 20]. Other examples are discussed below in the concluding section.

Widom-Larsen theory: on pp. 4 in W & L's *EPJC* paper (2006)

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Barmina *et al*. (Russia, arXiv 2013)

Widom-Larsen explanation for production and destruction of Tritium

Summary of W-L reactions that we believe better account for their claimed results:

Note: asterisk * on electron e^{-*} indicates that an electron has increased mass from quantum many-body collective effects; "ulm" subscript on neutron n_{ulm} indicates it has ultra low momentum which means it is at energy vastly below thermal neutrons, i.e. <<<<<< 0.025 eV

Production of neutrons (n):

$$e^{-*} + p^{+} \longrightarrow 1\, n_{ulm} + \nu_e$$

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

$$e^{-*} + t^{+} \longrightarrow 3\, n_{ulm} + \nu_e$$

Production of Deuterium (d^+):

$$n_{ulm} + p^{+} \longrightarrow d^{+} + \gamma_{prompt}$$

Neutron capture cross-section on protons ([1]H or 1_H) measured at thermal energies = 0.332 barns

Prompt gamma converted to infrared photons by heavy electrons per W-L

Measured Deuterium ([2]H or 2_H) neutron capture cross-section at thermal energies = 0.51 μbarns

Production of Tritium (t^+):

$$n_{ulm} + d^{+} \longrightarrow t^{+} + \gamma_{prompt}$$

Prompt gamma converted to infrared photons by heavy electrons per W-L; see Lattice patent US #7,893,414 B2

Destruction of Tritium (t^+) by conversion into neutrons that are then locally captured:

Per 1/v rule, ultra low momentum (ulm) neutrons have enormous capture cross-sections on local atoms (Z, A); A + 1 product may be stable/unstable, e.g. β-decay

$$e^{-*} + t^{+} \longrightarrow 3\, n_{ulm} + \nu_e$$

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

Any prompt gammas resulting from neutron captures on local atoms are converted into infrared photons (heat) by heavy electrons

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Barmina *et al*. (Russia, arXiv 2013)

- ✓ Chart to right based on measured data from ENDF nuclear database
- ✓ So-called 1/*v* rule states that measured neutron capture cross-sections are ~proportional to 1.0 divided by *v*, where *v* is neutron velocity expressed in meters/sec
- ✓ Below thermal energies at 0.025 eV, capture cross-section is ~linear inverse function of neutron energy
- ✓ If capture cross-sections of ULM neutrons could be measured, they would be way out beyond the left-side margins of the adjacent chart
- ✓ All isotopes shown in the chart would have extremely large capture cross-sections for ULM neutrons

Neutron capture cross-sections vs. neutron energy

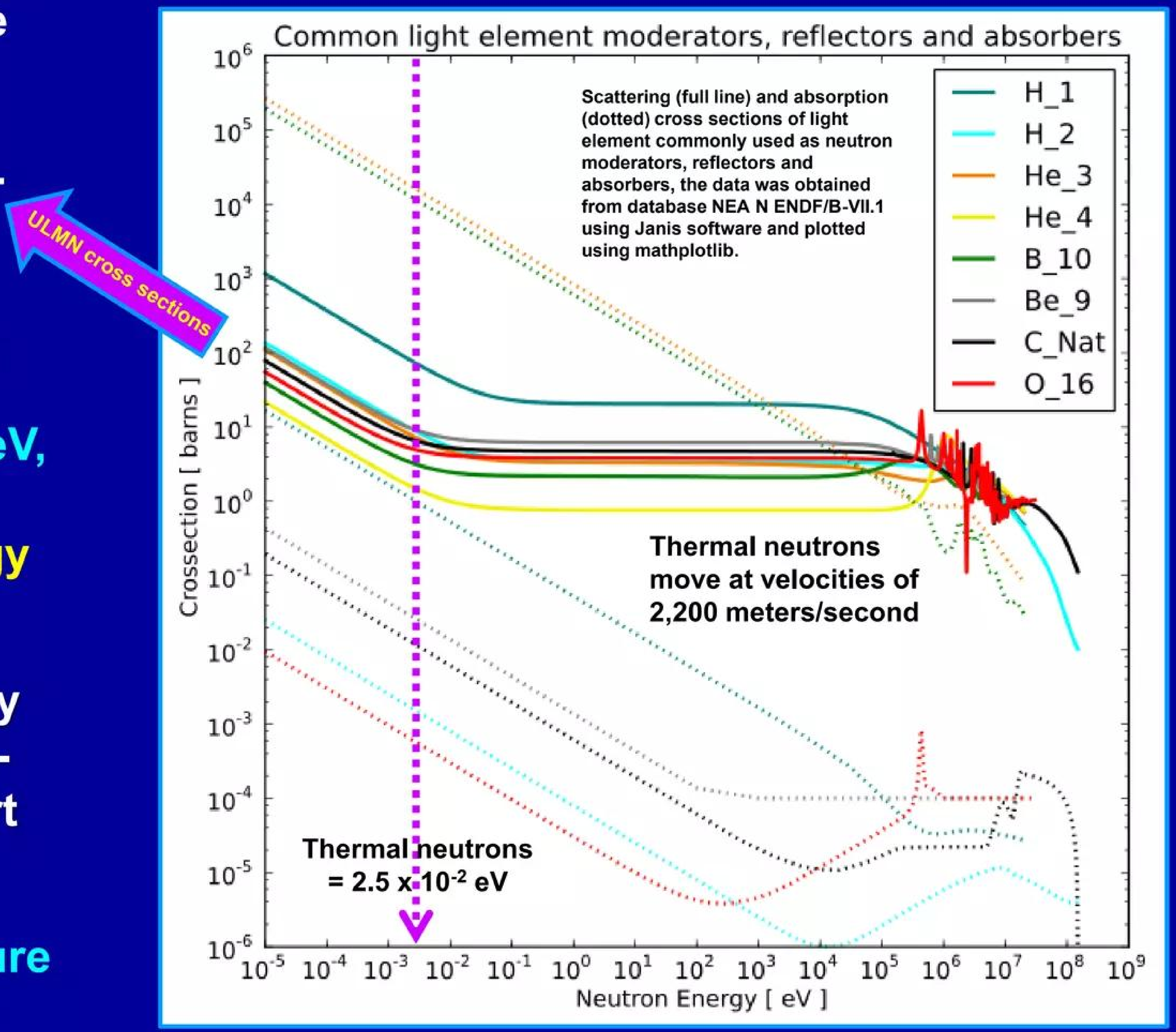

Figure source: Wikipedia https://en.wikipedia.org/wiki/Neutron_cross_section

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Conclusions re Barmina *et al*.

Their experimental data appears to be correct but their theory is flawed

- ✓ **Assuming it has been correctly and accurately measured and independently confirmed by third parties, their new data may well be important because it:**
  - **Provides good evidence for Tritium nucleosynthesis via electroweak neutron production and capture on Deuterium in condensed matter using combination of electrical currents and laser irradiation to provide input energy that drives W-L many-body collective neutron production**
  - **Provides indirect inferential evidence for the importance of degree of admixtures of different hydrogen isotopes with respect to maintaining quantum coherence in many-body 'patches' of entangled, collectively oscillating protons, deuterons, or tritons (or admixtures thereof) found in micron-scale Widom-Larsen LENR-active surface sites on hydrides**
- ✓ **Barmina *et al.*'s theoretical speculations that they claim explain their data involve strange, non-standard terminology that frankly seems to disguise use of some elements of the already published Widom-Larsen theory of LENRs (which they do not cite). Unlike Barmina *et al.*, we do not need to invoke any 'new nuclear physics' to explain their interesting reported experimental data**

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Misapprehensions about nuclear decay rate shifts

Seeming changes are likely to be unrecognized LENR transmutations

- ✓ **Somewhat confusingly, Barmina *et al*. refer to a so-called *"accelerated decay"* of Tritium when, *even by their own theoretical construct*, it is really a case of conversion into neutrons, NOT a change in the intrinsic $_1H^3$ nuclear decay rate constant**

- ✓ **During the past decade or so, there have been increasing numbers of experimental reports published in various peer-reviewed journals in which authors claimed to have observed changes in intrinsic nuclear decay rate constants of certain isotopes/elements**

- ✓ **Some of these observations are probably correct, especially in the case of beta-decaying isotopes that are interacting with incident neutrino fluxes (see Lattice SlideShare documents http://www.slideshare.net/lewisglarsen/lattice-energy-llc-changes-in-solar-neutrino-fluxes-alter-nuclear-betadecay-rates-on-earthjune-3-2011 and http://www.slideshare.net/lewisglarsen/lattice-energy-llcobserved-variations-in-rates-of-nuclear-decaynov-23-2012)**

- ✓ **In certain other cases, experimental data may have just been improperly measured/interpreted**

- ✓ **Importantly, there is probably a subset of such anomalous reported data in which experimentalists were blithely unaware of any possibility that LENR transmutations could be occurring inside their experimental systems. In such cases, the measured parameter(s) indicating a given nuclear decay rate, say intensities of a series of gamma emission lines, changes because the isotope(s) producing the gammas being measured has/have simply captured W-L ULM neutrons and been *transmuted* to other different --- perhaps even stable --- isotope(s); ergo, measured isotopes' intrinsic nuclear decay rate constants *did not really change* during such types of experiments**

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Reifenschweiler "*effect*" could be conversion of Tritium into neutrons

Seeming changes are likely to be unrecognized LENR transmutations

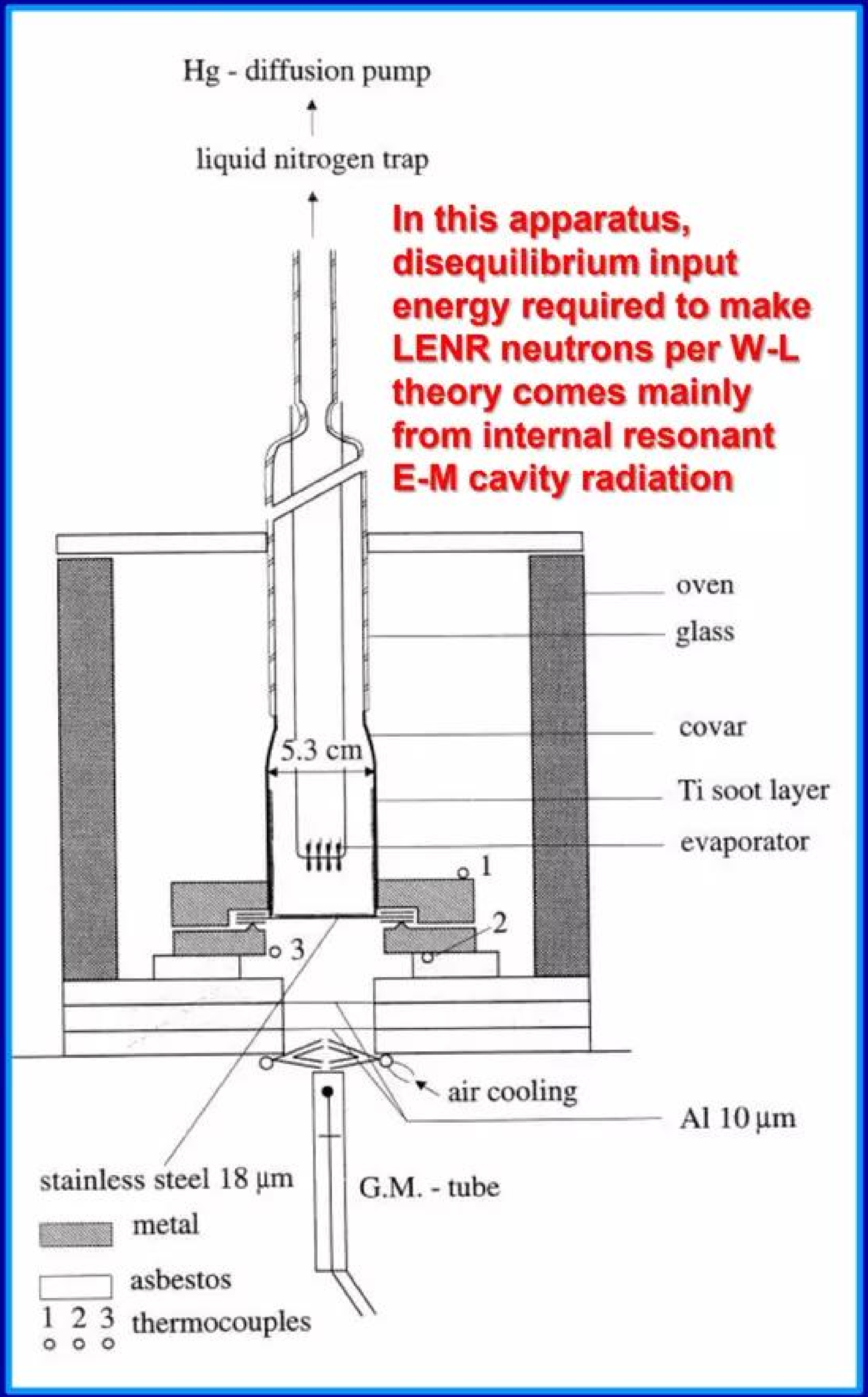
Reference:

"*Reduced radioactivity of tritium in small titanium particles*"
O. Reifenschweiler [work carried out at the Philips Research Laboratories, Eindhoven, The Netherlands]
Physics Letters A 184 pp. 149 - 155 (1994)
http://www.lenr-canr.org/acrobat/Reifenschwreducedrad.pdf

Abstract:

"By heating a $TiT_{0.0035}$ preparation consisting of extremely small monocrystalline particles ($\phi \approx 15$ nm) a decrease of the radioactivity by 40% was observed. In further experiments the concentration of tritium in such preparations was varied (TiT_x experiments) showing that the radioactivity of the tritium increased less than proportionally to its concentration. Careful analysis of the experiments seems to rule out the possibility of trivial errors. A provisional hypothetical explanation is formulated."

Fig.1 copied from his paper



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Reifenschweiler "*effect*" could be conversion of Tritium into neutrons

Seeming changes are likely to be unrecognized LENR transmutations

- ✓ **Groping for an explanation of the anomalous, baffling experimental data, Reifenschweiler concluded rather reluctantly that, *"… tritons absorbed in the extremely small single Ti-crystals can combine into pairs and that the decay constant of such a pair is much smaller than that of a free triton."***

- ✓ **Thanks to the Widom-Larsen theory, what we happen to know now that Otto *didn't* know when he pondered these data, is that neutron-catalyzed LENRs inside his particular experimental apparatus can be understood in the context of resonant electromagnetic cavities; for details see Slide #48 in http://www.slideshare.net/lewisglarsen/lattice-energy-llcnickelseed-lenr-networksapril-20-2011 ; concept applies to several types of systems**

- ✓ **In Lattice's opinion, Otto Reifenschweiler's carefully collected, anomalous experimental data was probably correct and most likely accurately measured; unfortunately, he was hamstrung information-wise because *at that point in time* he had no idea that ULM neutrons could potentially be created from Tritium atoms in his prosaic experimental apparatus located at Phillips Research Laboratories in Eindhoven**

- ✓ **Please note that Reifenschweiler' clever, well-executed experiments are fully explainable with Widom-Larsen theory of LENRs; readers are invited to do exactly that as an interesting intellectual exercise (see hint given above re LENRs in resonant E-M cavities found on various length scales)**

Fig.2 copied from Otto's paper

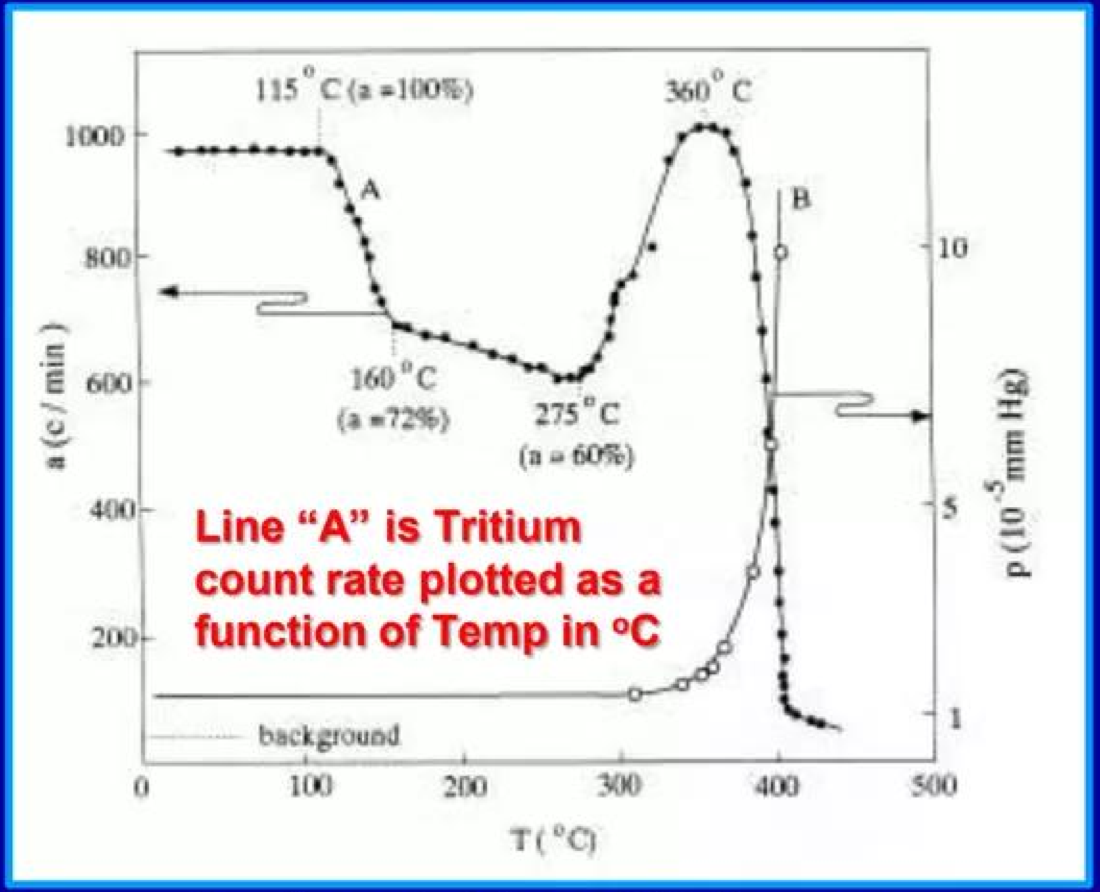
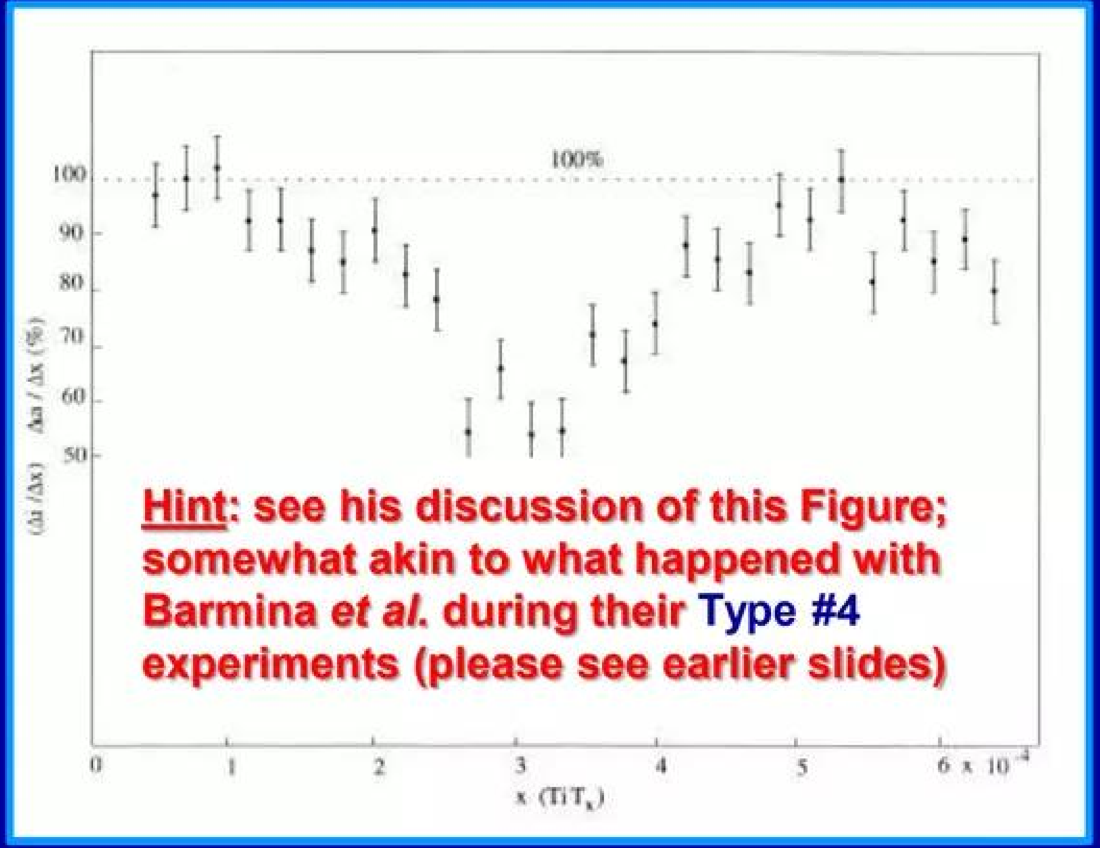


Fig.3 copied from Otto's paper



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Commercializing a Next-Generation Source of Green Nuclear Energy

Experimental opportunities and final thoughts

Using nanoparticles, surface plasmons can absorb, concentrate, and 'beam' electromagnetic energy

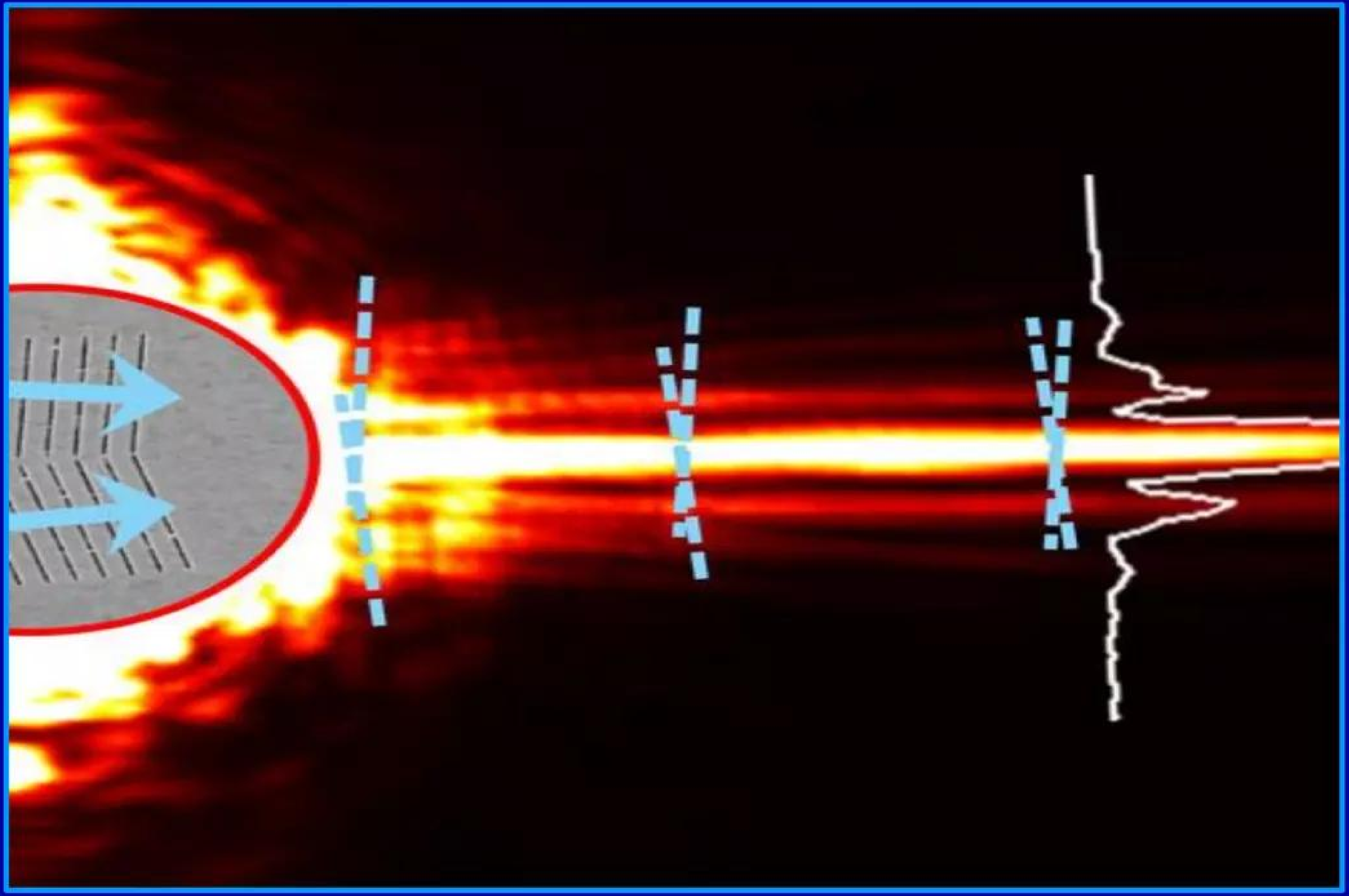

Image credit: P. Genevet (Harvard SEAS), caption, *"… cosine-Gauss plasmon beam, dubbed a 'needle beam,' that propagates without diffraction*", in "*Cosine-Gauss plasmon beam: a localized long-range nondiffracting surface wave,"* J. Lin *et al.*, *Physical Review Letters* 109 pp. 093904 (2012); also please see P. Genevet *et al.*, "*Generation of two-dimensional plasmonic bottle beams*" (2013) at http://www.seas.harvard.edu/capasso/wp-content/uploads/publications/oe-21-8-10295.pdf

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Opportunities for further experimental work

LENRs are likely to become a very exciting, fruitful new area of research

- ✓ **For reasons we have previously enumerated, Barmina *et al.*'s experimental results are potentially important; in Lattice's opinion, it would definitely be worthwhile for other researchers to attempt to independently replicate the recent Russian work and then publish their results in mainstream peer-reviewed journals**

- ✓ **Barmina *et al.*'s use of Selenium (Se is a non-metal) as an irradiation target was novel and quite interesting; as far as we know, it is the first time that LENR effects have ever been observed in conjunction with Selenium. In context of W-L theory, Se is understandable as a viable LENR substrate because Hydrogen selenide (H_2Se) forms at T > 300°C in presence of gaseous hydrogen; this is easily obtained in areas of bulk target surfaces undergoing laser ablation. Further experimentation with Selenium could be quite interesting in context of new LENR-active materials**

- ✓ **Please note that: analogous to Barmina *et al.* observing formation of Tritium as a result of LENR neutron captures on Deuterium, other LENR experimentalists have seen anomalous production of Deuterium from Hydrogen in high-pulsed-current electric arc 'beams' on various metallic targets; this result is understandable with the Widom-Larsen theory – for published data on these arc experiments please see:**

  http://newenergytimes.com/v2/library/2005/2005Adamenko-Track-Measurements.pdf

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Final thoughts

Enough is now known about LENRs to begin commercialization

<u>In our *Pramana* W-L theory review paper (2010) we concluded by saying that</u>:

"The analysis presented in this paper leads us to conclude that realistic possibilities exist for designing LENR devices capable of producing 'green energy', that is, production of excess heat at low cost without lethal nuclear waste, dangerous γ-rays or unwanted neutrons. The necessary tools and the essential theoretical know-how to manufacture such devices appear to be well within the reach of the technology available now. Vigorous efforts must now be made to develop such devices whose functionality requires all three interactions of the Standard Model acting in concert."

W-L theory: many-body collective electroweak production of neutrons in condensed matter

In [1], metallic hydride surfaces on which plasma oscillations exist were analysed. It was shown that the collective plasma oscillations on the surface could contribute some of their electric energy to an electron so that the following reaction was kinematically allowed:

$$W_{\text{electric}} + e^- + p \rightarrow n + \nu_e. \quad (1)$$

The relevant scale of the electric field $\mathcal{E}$ and the plasma frequency Ω needed to accelerate electrons to trigger neutron production is found to be

$$\frac{c\mathcal{E}}{\Omega} = \left(\frac{mc^2}{e}\right) \approx 0.5 \times 10^6 \text{ V}, \quad (2)$$

where c is the speed of light, m is the mass and $(-e)$ is the charge of the electron.

The particular condensed matter environment leads in this case to ultracold (that is, ultralow momentum) neutrons. These ultracold neutrons produced, have extraordinarily large nuclear absorption cross-sections and thus a high probability of producing nuclear transmutations and an extremely low probability of neutrons escaping beyond micron scale and smaller surface regions in which they are formed. There is also a high suppression in the production of high-energy γ-rays [2]. For such metallic chemical cells, comprehensive calculations of the rates of LENRs [3] were made which confirmed a robust production of new elements.

Srivastava, Widom, and Larsen: on pp. 3 in *Pramana* paper (2010)

"I cannot help fearing that men may reach a point where they look on every new theory as a danger, every innovation as a toilsome trouble, every social advance as a first step toward revolution, and that they may absolutely refuse to move at all."[1.]

"In a revolution, as in a novel, the most difficult part to invent is the end."[2.]

Alexis de Tocqueville (1840)

1. *"Democracy in America"* Volume II Book Three, Chapter XXI – "While great revolutions will become more rare" (1840)
http://www.gutenberg.org/files/816/816-h/816-h.htm
http://www.gutenberg.org/files/816/816-h/816-h.htm#link2HCH0062

2. *"The Recollections of Alexis de Tocqueville"*, Alexis de Tocqueville, pp. 71 Macmillan (1896)

Image credit: caption "Metallic plasmonic nanostructures coupled with graphene" from "*Plasmon resonance enhanced multicolour photodetection by graphene,*" Y. Liu *et al.*, *Nature Communications* 2 article #579 doi:10.1038/ncomms1589 (2011)