Lattice Energy LLC

Commercializing a natural second-generation radiation-free energy source

Low energy neutron reactions (LENRs) and positive holes

Seismicity, terrestrial nucleosynthesis, and the Deep Biosphere

Paradigm shifts in geophysics, geochemistry, and biology

Earth

Image credit: NASA

Lewis G. Larsen

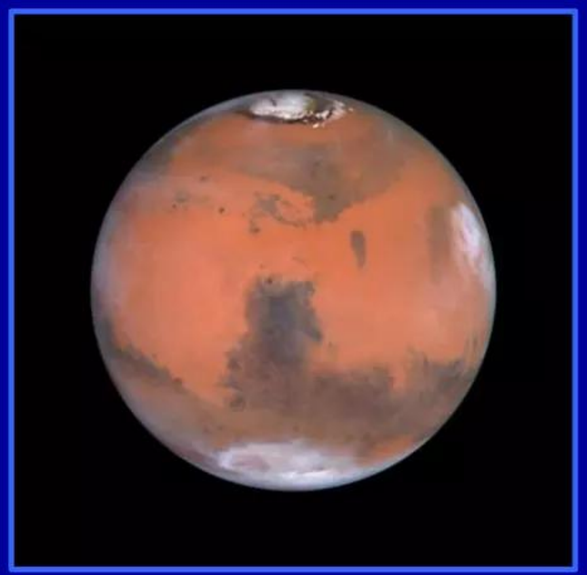
President and CEO
Lattice Energy LLC

December 22, 2014

"In any field,
find the strangest thing
and then explore it."

John Archibald Wheeler

Other rocky planets



Mars - image credit: NASA

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http://www.slideshare.net/lewisglarsen/presentations

Summary: key take-aways

- ✓ Freund p-holes provide a new electronic mechanism for transferring and dissipating energy in Earth's upper crust besides known mechano-acoustic seismic P- and S-wave processes - this is a paradigm shift in geophysical thinking
- ✓ p-holes can power electric bacteria and LENR neutron-catalyzed nucleosynthesis (transmutation of elements) in Earth's crust; these create measurable products at low rates over geological time - paradigm shift in geochemistry
- ✓ There is published experimental evidence that supports these conjectures and further suggests that p-holes and LENRs facilitate earthquakes and other seismic processes
- ✓ Geophysical processes on Earth may be modulated by neutrino fluxes coming from the Sun via e + p neutrino interactions; explains otherwise inexplicable Russian data

Image credit: Royal Society of Chemistry (2012)

Contents

Commercializing a natural second-generation radiation-free energy source

LENRs are paradigm-shifting nuclear energy technology

Image credit: co-author Domenico Pacifici
From: "Nanoscale plasmonic interferometers for multispectral, high-throughput biochemical sensing"
J. Feng *et al.*, *Nano Letters* pp. 602 - 609 (2012)

Laura 13

No deadly gamma radiation …

No dangerous energetic neutron fluxes …

Insignificant production of hazardous radwastes

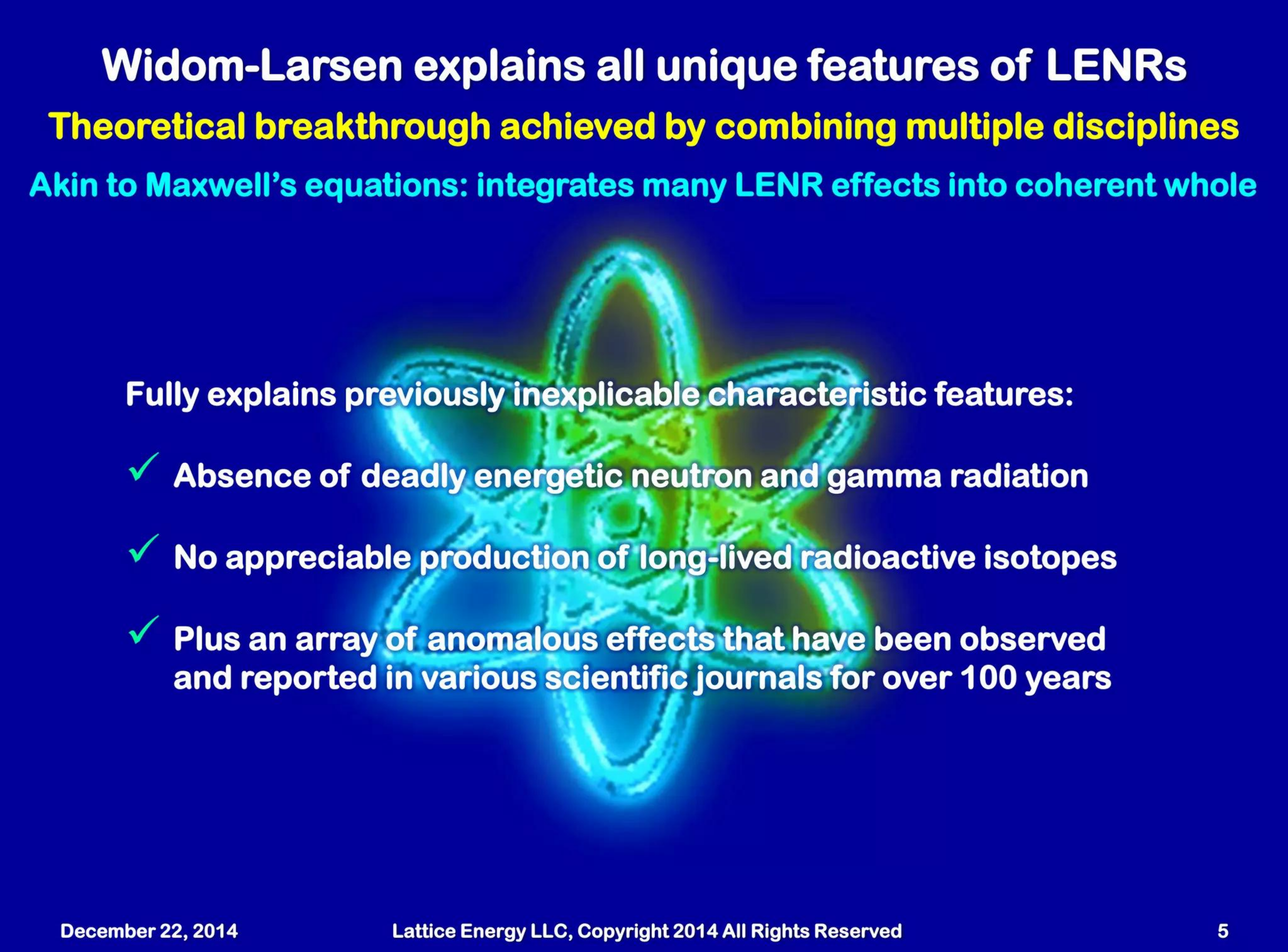
Revolutionary, disruptive, and environmentally safe

Occurs in Nature as well as in man's laboratories

Widom-Larsen explains all unique features of LENRs

Theoretical breakthrough achieved by combining multiple disciplines

Akin to Maxwell's equations: integrates many LENR effects into coherent whole



Fully explains previously inexplicable characteristic features:

- ✓ Absence of deadly energetic neutron and gamma radiation
- ✓ No appreciable production of long-lived radioactive isotopes
- ✓ Plus an array of anomalous effects that have been observed and reported in various scientific journals for over 100 years

Widom-Larsen theory specifies key LENR requirements

Necessary prerequisites for initiating green transmutation processes

Hydrogen (protons or deuterons) and heavy-mass electrons are key reactants

- ✓ Substantial quantities of Hydrogen isotopes must be brought into intimate contact with fully-H-loaded metallic hydride-forming metals (or non-metals like Se); e.g., Palladium, Platinum, Rhodium, Nickel, Titanium , Tungsten, etc. Please note that collectively oscillating, 2-D surface plasmon (SP) electrons are intrinsically present and cover the surfaces of such metals. At full lattice loading (saturation) of Hydrogenous isotopes, many-body, collectively oscillating island-like patches of protons (p^+), deuterons (d^+), or tritons (t^+) will form spontaneously at random locations scattered across such surfaces

- ✓ Or, delocalized collectively oscillating π electrons that comprise the outer covering surfaces of fullerenes, graphene, benzene, and polycyclic aromatic hydrocarbon (PAH) molecules behave identically to SPs; when such molecules are hydrogenated, they can create many-body, collectively oscillating, entangled quantum systems that, per W-L theory, are functionally equivalent analogues of loaded metallic hydrides. In this case, LENRs are triggered on aromatic rings; strong tendency to transmute ring Carbon atoms

- ✓ Born-Oppenheimer approximation breaks down in tiny surface patches of contiguous aggregations of collectively oscillating p^+, d^+, and/or t^+ ions; this enables E-M coupling between nearby SP or π electrons and hydrogen ions at such locations; creates nuclear-strength local electric fields > 2 x 10^{11} V/m; effective masses of electrons in that field are then increased to some multiple of an electron at rest ($e \rightarrow e^*$) determined by required ~simultaneous energy input(s) --- particle physicists call this “mass renormalization”

Basic reactions in Widom-Larsen theory are simple

Protons or deuterons react directly with electrons to make neutrons

Neutrons are then captured by other atoms → catalyze nuclear transmutations

Input energy comes from E-M fields

Collective many-body quantum effects: many electrons each donate little bits of energy to a much smaller number of electrons that are also embedded in same high electric field

Ultralow energy neutrons mostly captured locally

Quantum electrodynamics (QED): smaller number of electrons that absorb energy from electric field can increase their effective masses ($m = E/c^2$) to point where they can react directly with protons (or deuterons) to make neutrons and neutrinos

$$\text{Energy}_{\text{E-field}} + e^-_{sp} \rightarrow e^{-*}_{sp} + p^+ \rightarrow n^0 + \nu_e$$

ν_e neutrinos: ghostly unreactive photons that fly-off into space; n^0 neutrons: capture on nearby atoms

Neutron-capture-catalyzed transmutations release energy stored in atoms:

Neutrons + atomic nuclei —Transmutation→ **heavier elements + decay products**

Releases vast amounts of stored nuclear binding energy as energetic particles/photons that create heat

Widom-Larsen posits that LENRs are multi-step process

Summary of key steps that must occur in LENR transmutation process

Five-step green radiation-free process occurs in 300 - 400 nanoseconds or less

1. Collectively oscillating, quantum mechanically entangled, many-body patches of hydrogen (either protons or deuterons) form spontaneously on surfaces

2. Born-Oppenheimer approximation spontaneously breaks down, allowing E-M coupling between local surface plasmon electrons and patch protons; enables application of input energy to create nuclear-strength local electric fields >> 10^{11} V/m - increases effective masses of surface plasmon electrons in patches

3. Heavy-mass surface plasmon electrons formed in many-body patches can react directly with electromagnetically interacting protons; process creates neutrons and benign neutrinos via a collective electroweak $e + p$ reaction

4. Neutrons collectively created in patch have ultra-low kinetic energies; almost all absorbed by nearby atoms - few neutrons escape into environment; locally produced or ambient gammas converted directly into infrared photons by unreacted heavy electrons (US# 7,893,414 B2) - no deadly gamma emissions

5. Transmutation of elements and formation of craters at active sites then starts

Radiation-free green transmutations in mild conditions

Electrons react directly with protons to make neutrons and neutrinos

Reactions are 'green': no deadly emissions of energetic neutrons and gammas

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

Non-stellar neutron production in condensed matter under mild conditions:

Collective many-body processes require external input energy

$$e^{-*} + p^{+} \rightarrow n + \nu_e$$ Electric fields dominate

$$e^{-} + p^{+} \rightarrow lepton + X$$ Magnetic fields dominate

Electroweak nuclear reactions produce neutrons (n) and neutrinos (ν_e)

Transmutation of elements and star-like nucleosynthesis in labs and Nature:

Neutron capture-driven transmutation in Earthly environs

$$n + (Z, A) \rightarrow (Z, A+1)$$ Neutron capture

$$(Z, A+1) \rightarrow (Z+1, A+1) + e_{\beta}^{-} + \bar{\nu}_e$$ Beta decay

Unstable neutron-rich products of neutron captures will undergo beta$^-$ decay
Create heavier stable isotopes or heavier elements along rows of Periodic Table

Widom-Larsen identifies ideal types of input energy

External source of input energy required to produce LENR neutrons

Electric currents and/or oscillating electromagnetic fields ideal for input energy

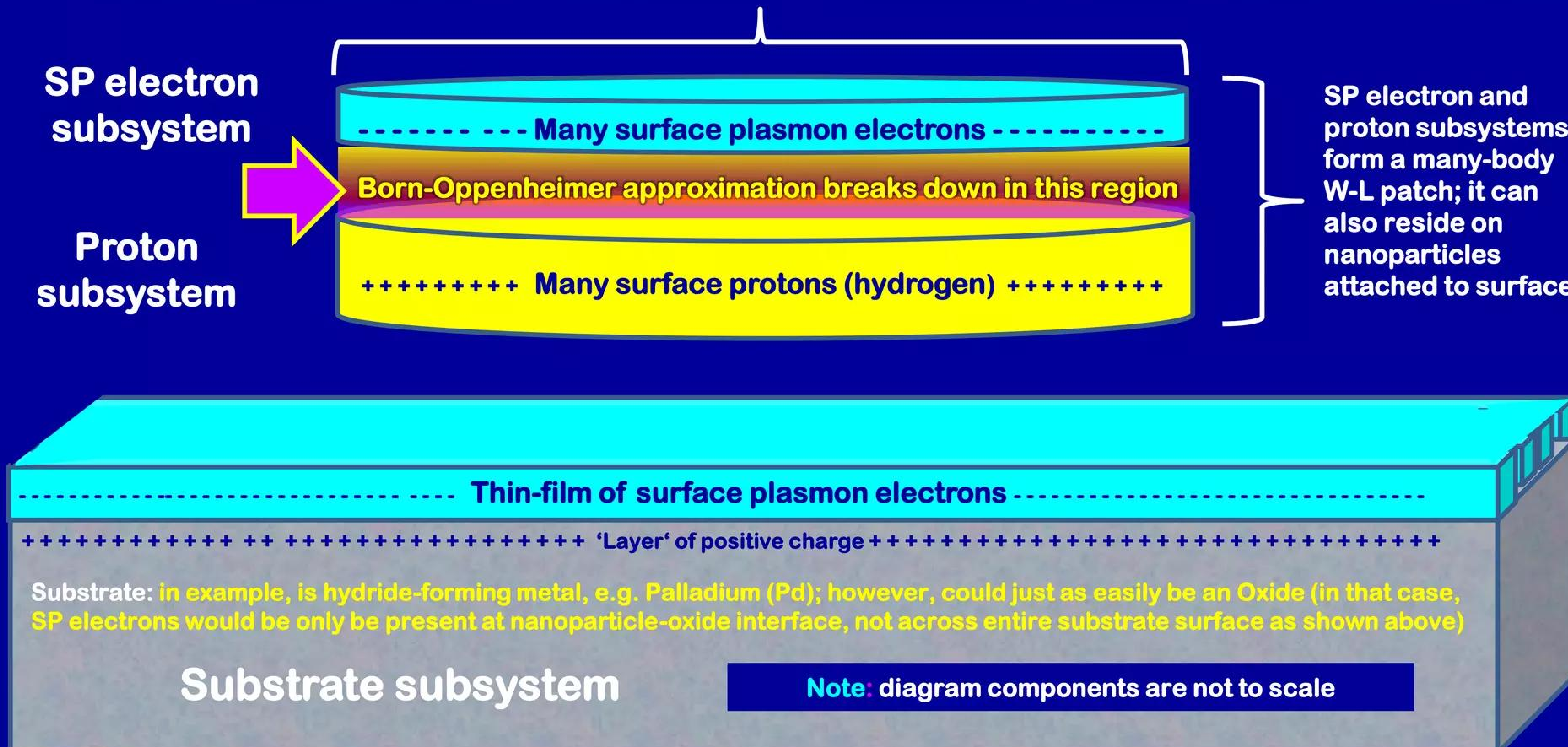
- ✓ LENR sites must be subjected to external non-equilibrium fluxes of charged particles or electromagnetic (E-M) photons that are able to transfer input energy directly to many-body SP or π electron surface 'films'. Examples of external energy sources include (they may be used in combination): electric currents and/or rapidly oscillating electric fields; E-M photons emitted from coherent lasers or incoherent IR-resonant E-M cavity walls, etc.; pressure gradients of p^+, d^+, and/or t^+ ions imposed across site surfaces; currents of other ions crossing SP electron 'film' in either direction (i.e., ionic fluxes); etc. Such sources can provide input energy required to surpass certain minimum H-isotope-specific electron-mass thresholds that allow production of ultralow energy neutron fluxes via collective $e^* + p^+$, $e^* + d^+$, or $e^* + t^+$ weak interactions
- ✓ N.B. please note again that surface plasmons (SP) are collective, many-body electronic phenomena closely associated with interfaces. For example, they can exist at gas/metal interfaces or metal/oxide interfaces. Thus, surface plasmon oscillations will almost certainly also be present at contact points between purely metallic surfaces and adjacent layers and/or nanoparticles composed of metallic oxides, e.g., PdO, NiO, or TiO_2, etc., or vice-versa

Anatomy of a microscopic LENR-active surface site

Conceptual overview of many-body patches that form on surfaces

SP electrons and protons all oscillate collectively and mutually Q-M entangled

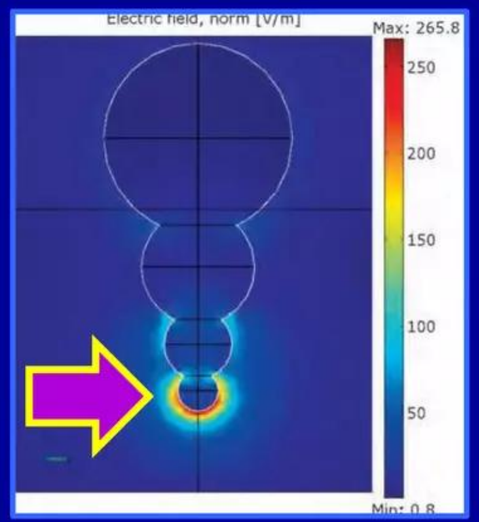
Diameters of many-body patches randomly range from several *nm* up to perhaps ~100⁺ microns



Huge increase in local E-field strengths on nanoscale

Nanostructures of right shapes/compositions amplify electric fields

Details of nanoparticulate features on *nm* to μ length-scales very key to LENRs

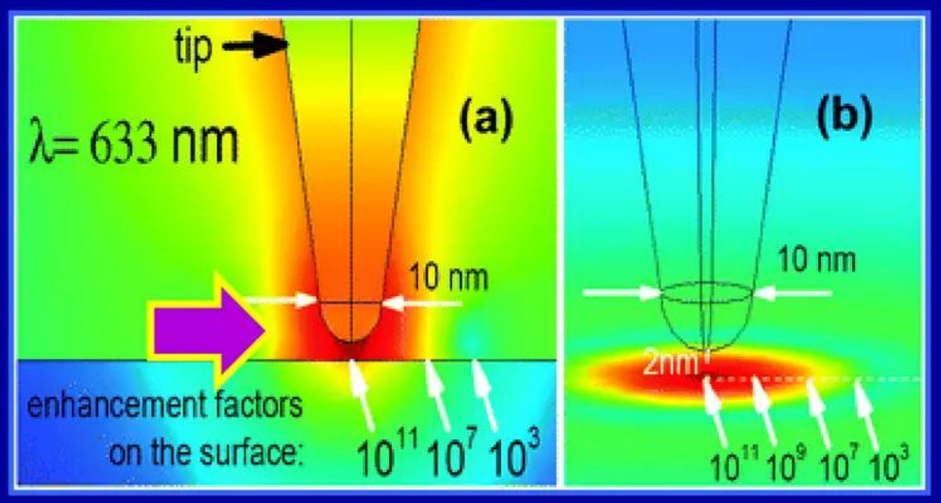


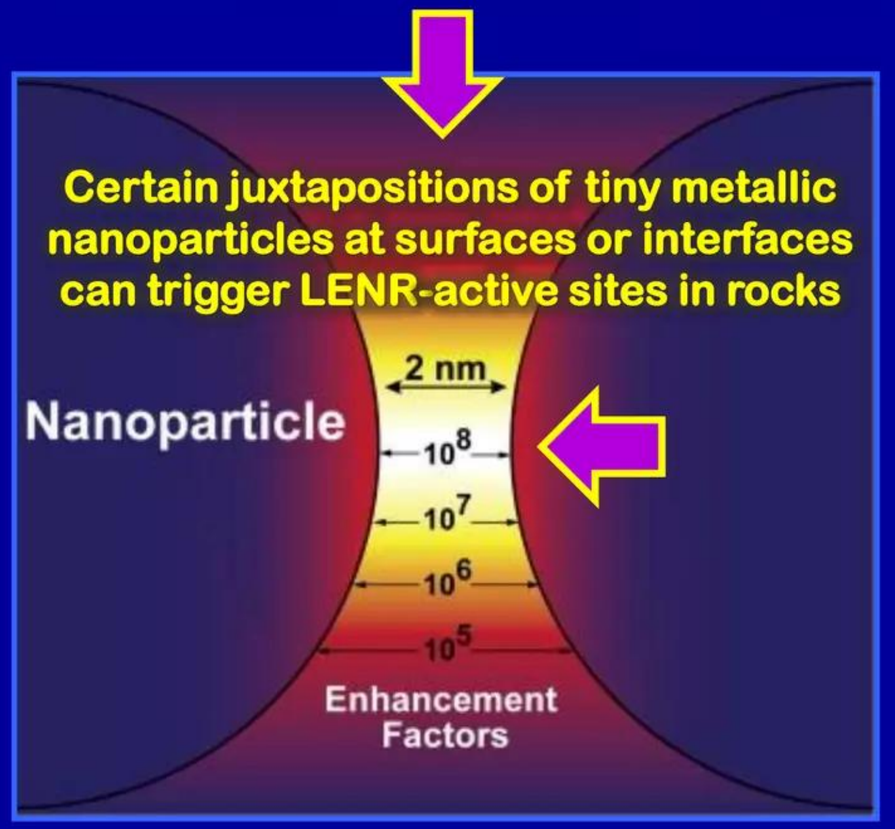
Electric field enhancement at nano-antenna tip: R. Kappeler *et al.* (2007)

Above: classic Mandelbrot fractal form

Sharp tips exhibit so-called "lightning rod effect" by creating enormous local enhancement in electric field strengths

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



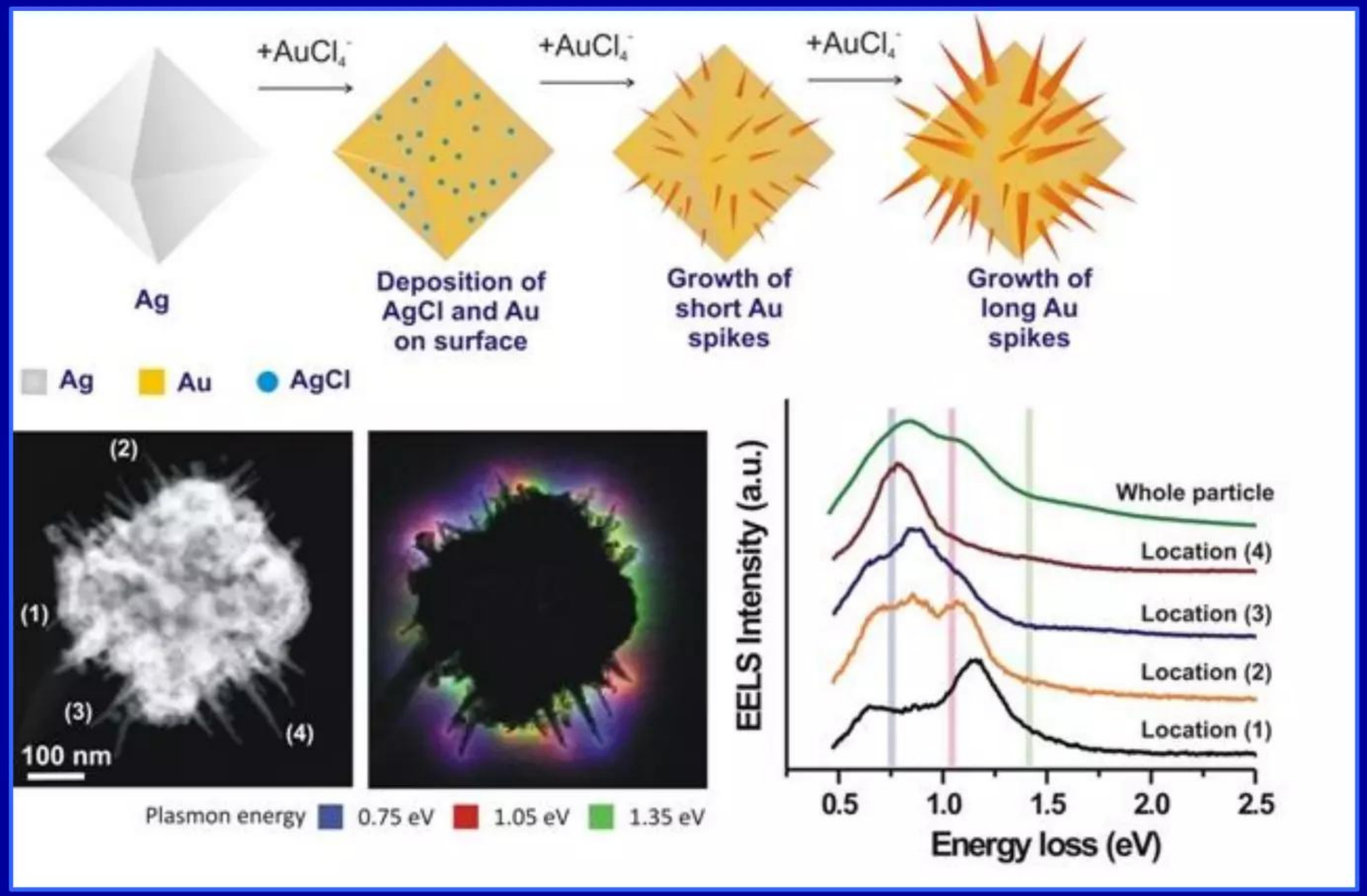


Nanoparticle shapes can intensify ambient electric fields

Grow out in Nature and are readily fabricated in nanotech laboratories

Surface plasmons are present on surfaces of metallic NPs embedded in oxides

"Synthesis of spiky Ag-Au octahedral nanoparticles and their tunable optical properties" S. Pedireddy *et al.*, *J. Phys. Chem. C* 117 pp. 16640 - 16649 (2013)



Input energy creates very high electric fields in LENR sites

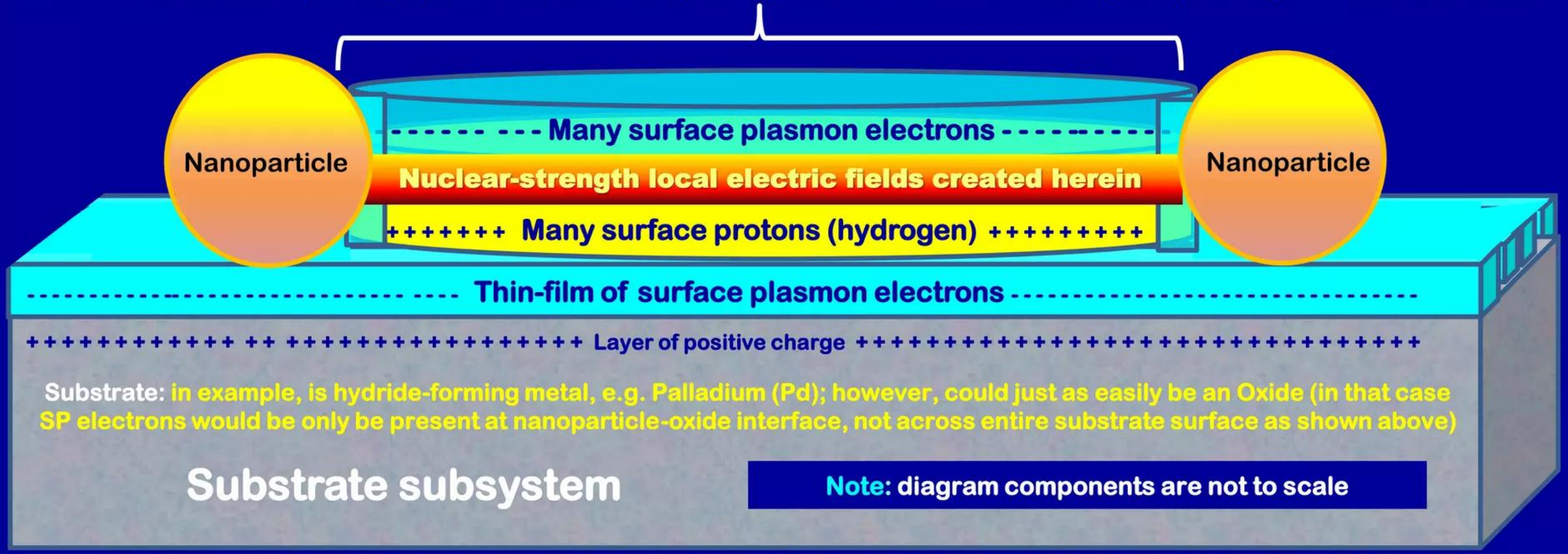
Born-Oppenheimer breakdown enables nuclear-strength local E-fields

Huge electric fields increase effective masses of some patch SP electrons

Appropriate input energy will create local E-fields > 10^{11} V/m between nanoparticles that permit:

$$\text{Input energy}_{\text{E-field}} + e^-_{sp} \rightarrow e^{-*}_{sp} + p^+ \rightarrow n + \nu_e$$ [condensed matter surfaces]

Diameters of many-body patches randomly range from several *nm* up to perhaps ~100⁺ microns



LENRs occur in microscopic active sites found on surfaces

Many-body collections of protons and electrons form spontaneously

Ultralow energy neutrons are produced and captured close to LENR sites

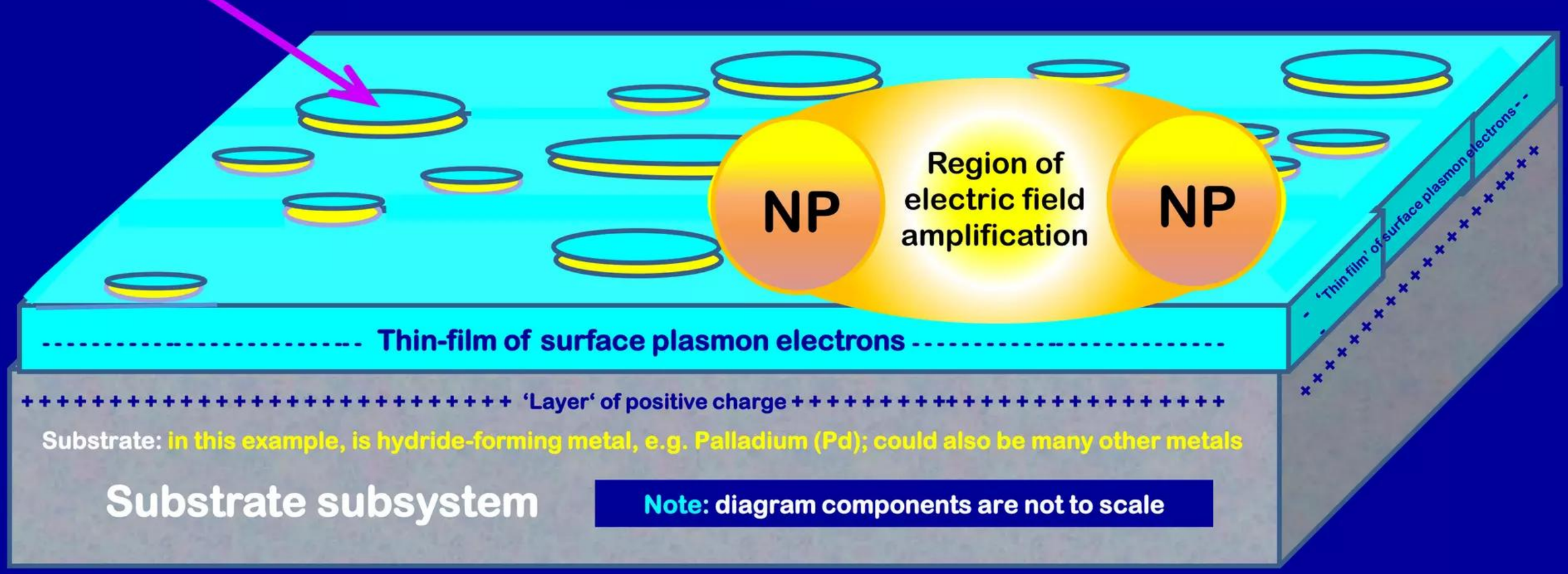
After being produced, neutrons will capture on nearby atoms:

$n + (Z, A) \rightarrow (Z, A+1)$ [local atoms 'compete' to capture neutrons]

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

Captures normally followed by β^- decays of neutron-rich intermediate LENR products

Intense heating in LENR-active sites will form μ-scale event craters on substrate surfaces

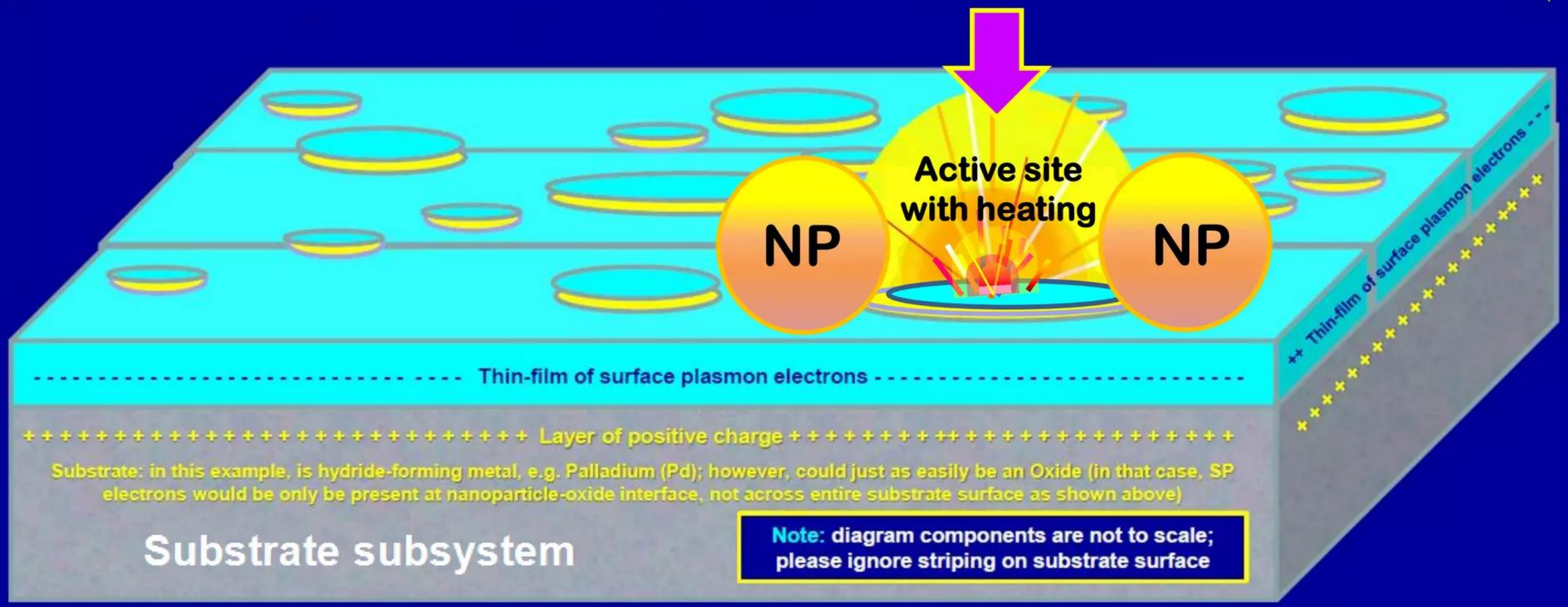


LENR-active sites only survive for ~200 - 400 nanoseconds

Intense heating destroys the local quantum coherence and site 'dies'

Releases nuclear binding energy stored in fuels and transmutes elements

Neutron capture process extremely fast: within picoseconds after being created



Explosive LENR 'hotspots' create distinctive surface craters ~2 - 100 microns in diameter

Observed on LENR-active substrates post-experiment with scanning electron microscopes (SEM)

LENR transmutation products have been observed in same areas with SIMS

Widom-Larsen identifies sources of heat in LENR sites

Heat released in tiny LENR-active sites comes from two key processes

Local temperatures in hotspots can reach 4,000 - 6,000º C for very brief periods

- ✓ Intense heat produced by LENR processes comes from:
  - Large population of unreacted, collectively oscillating heavy-mass SP or π electrons that directly convert dangerous gamma photons created by neutron captures and nuclear decay processes directly into benign infrared photons (IR - heat). Such IR is absorbed by and heats-up nearby matter; see Lattice's fundamental patent involving this novel process: US# 7,893,414 B2 issued on February 22, 2011
  - Energetic charged particles (e.g., alphas, betas, protons, deuterons, tritons) impacting materials in the nearby environment; heat-up local materials by transferring kinetic energy from such charged particles
- ✓ Note - emitted neutrino photons do not contribute to locally generated heat; they bleed-off some excess nuclear energy into deep space by emission of totally benign form of energetic electromagnetic radiation
- ✓ Heating is sufficient to flash-boil refractory metals and form craters

Physical evidence for LENRs can be found on surfaces

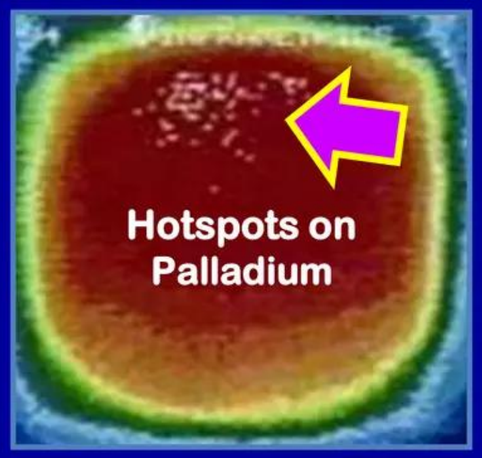
μ-scale crater formation is characteristic feature of LENR processes

Infrared emission from short-lived LENR-active sites seen in U.S. Navy video clip

- ✓ LENRs intrinsically occur in localized micron-scale LENR-active sites on ~planar surfaces or curved surfaces of nanoparticles
- ✓ Tiny LENR-active sites live for less than ~300 - 400 nanoseconds before being destroyed by intense heat; local peak temps range from 4,000 - 6,000° C; such LENR-active sites will spontaneously reform under right conditions in Nature or in engineered devices
- ✓ Microscopic 100-micron LENR hotspot release up to 5⁺ Watts of heat in less than 400 nanoseconds; create crater-like features on surfaces that are visible in SEM images and showing clear evidence for flash-boiling of precious and refractory metals
- ✓ Peak local LENR power density can hit > 1.0 x 10^{21} Joules/sec·m^3
- ✓ See U.S. Navy video clip of an LENR-active cathode surface that was imaged with a high speed infrared camera; as video runs it looks like fireflies flickering on-and-off at night in a summer field

100 μ crater in Palladium

IR video of LENR hotspots



http://www.youtube.com/watch?v=OUVmOQXBS68

Credit: P. Boss, U.S. Navy

Physical evidence for LENRs can be found on surfaces

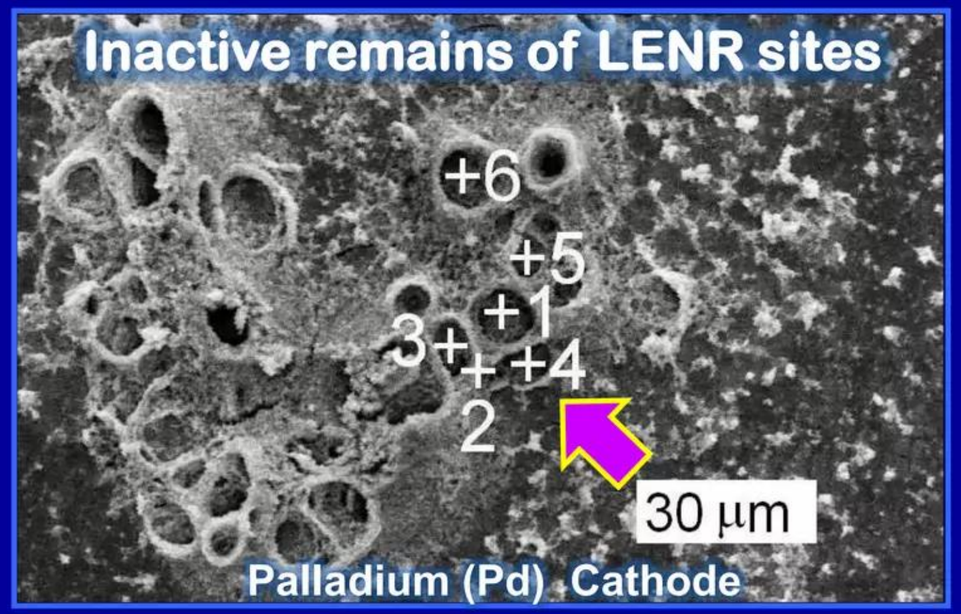
Palladium transmuted to Silver with ULM neutron capture and β-decay

Following nuclear reactions explain how Silver was produced in the experiments

neutron capture process — β^- nuclear decay process

[Multiple stable Palladium isotopes] Pd + n → [unstable neutron-rich Pd isotopes] → Ag [two stable Silver isotopes]

LENRs: Zhang & Dash (2007) - Fig. 8



Note: Pd boiling point = 2,970° C

Free copy of Zhang & Dash (2007) paper at:

http://www.lenr-canr.org/acrobat/ZhangWSexcessheat.pdf

LENRs: Zhang & Dash (2007) - Fig. 9

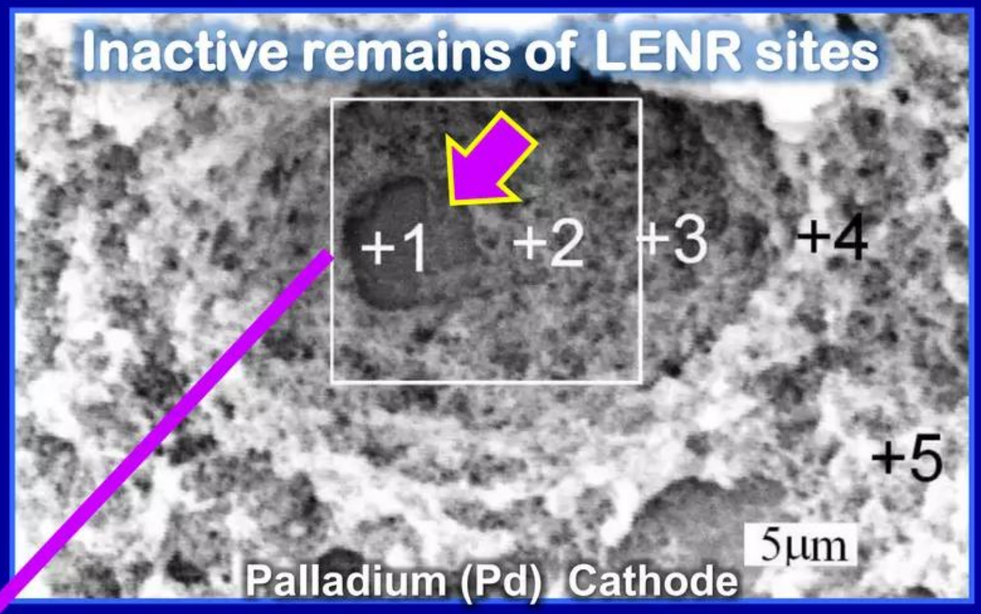


Fig. 9. SEM picture of crater at another time. SEM No.WS060607Pd-H-CC-i2-2kX

Quoting: "The most common finding is that Silver occurs in craters, such as those shown in Fig. 8. These craters with rims almost certainly formed during electrolysis. Pt deposition was concentrated on these protruding rims."

Zhang & Dash: Table IX. Relative atomic percent concentrations of Silver (Ag) in area and spots shown in Fig. 9							
Spot #	wa*	area**	+1	+2	+3	+4	+5
Ag/(Pd+Ag)	1.2 +/- 0.5	5.6 +/- 0.4	6.8 +/- 0.4	5.6 +/- 0.3	6.3 +/- 0.4	3.6 +/- 0.6	1.2 +/- 0.5

*wa = whole entire area comprising image in Fig. 9

** area = delimited by the white square outlined in Fig. 9

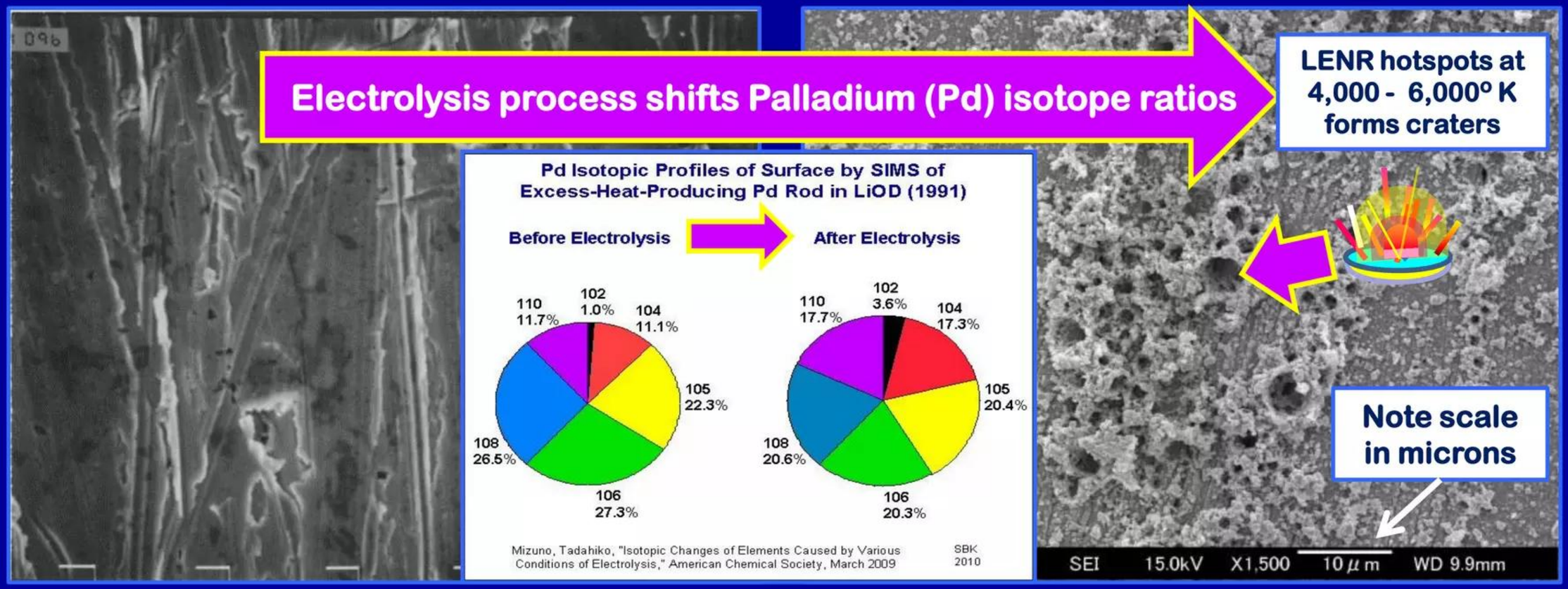
Physical evidence for LENRs can be found on surfaces

SEM-EDX and SEM-SIMS show transmutation products at crater sites

Mizuno *et al.* reported the results of chemical cell experiments at ICCF-17 (2012)

Before: relatively smooth surface

After: rugged terrain on micron-scales



Quoting Slide #5 caption in ICCF-17 presentation: "These photo are the Pd electrode before and after the electrolysis. Electrolysis was conducted for a long time, several day or several week. Typical current density was 20mA/cm^2. Here, you see the metal particle (100 nm or less) on the surface after electrolysis. Some of them are less than 10 nano-meter of size."

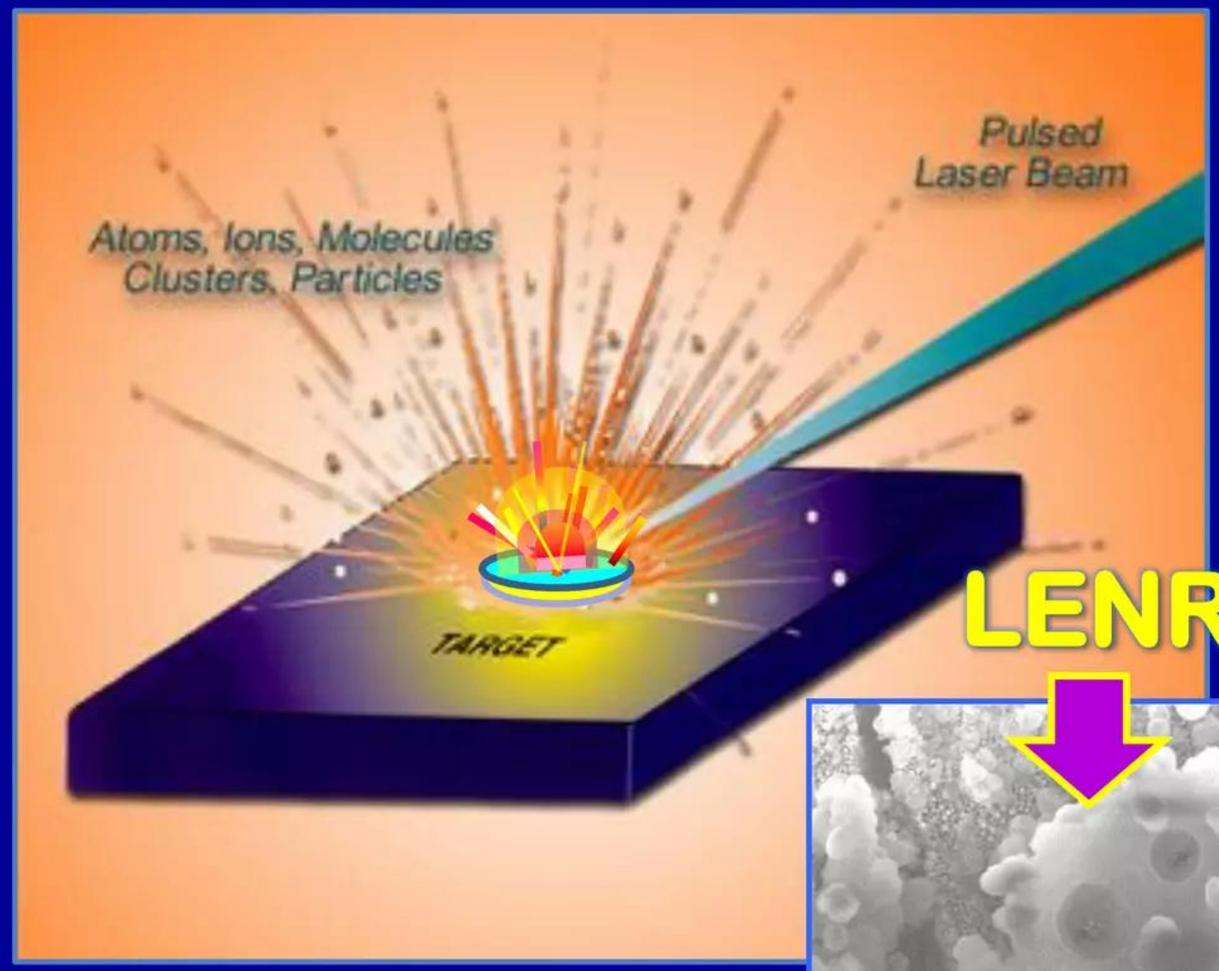
Source: 41-slide ICCF-17 conference (Aug. 12-17, 2012, Daejeon, Korea) presentation titled, "Theoretical Analysis of Chemically Assisted Nuclear Reactions (CANR) in Nanoparticles," T. Mizuno, M. Okuyama, Y. Ishikawa, and T. Oheki

Copy of slides at: http://newenergytimes.com/v2/conferences/2012/ICCF17/papers/Mizuno-Theoretical-Analysis-Slides-ICCF-17.pdf

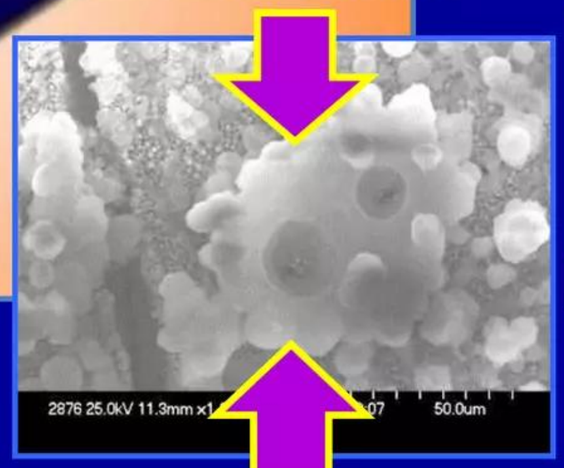
Effects on LENR-active sites akin to pulsed-laser ablation

LENR craters' sharp walls indicate fast nanosecond-scale heat flashes

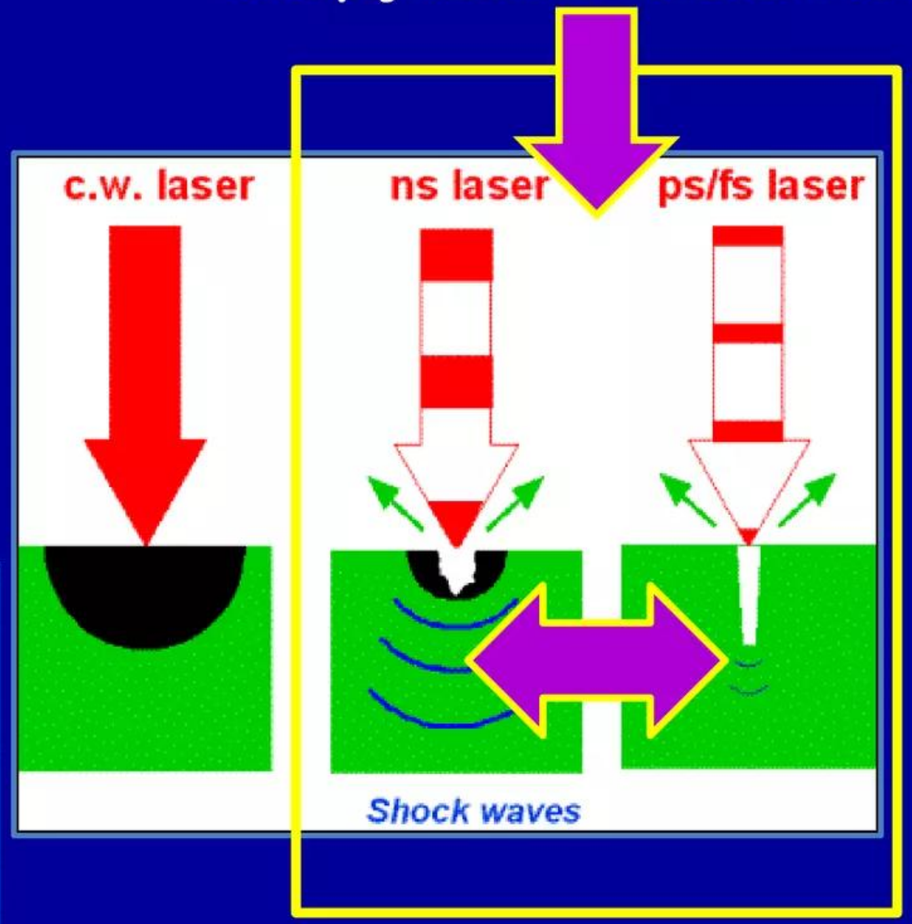
Heat flash blasts-out crater, ionizes matter and then transmutes elements locally



LENR



Shorter-duration laser pulses produce craters with steeper, sharply defined vertical walls



Crater on Palladium surface: P. Boss, U.S. Navy

LENR-active sites have measurable acoustic signatures

U.S. Navy researchers detected "mini-explosions" on device surfaces

Source: "Complex oxide-noble metal conjugated nanoparticles" J-L. Guo et al., *Advanced Materials* 25 pp. 2040 - 2044 (2013)

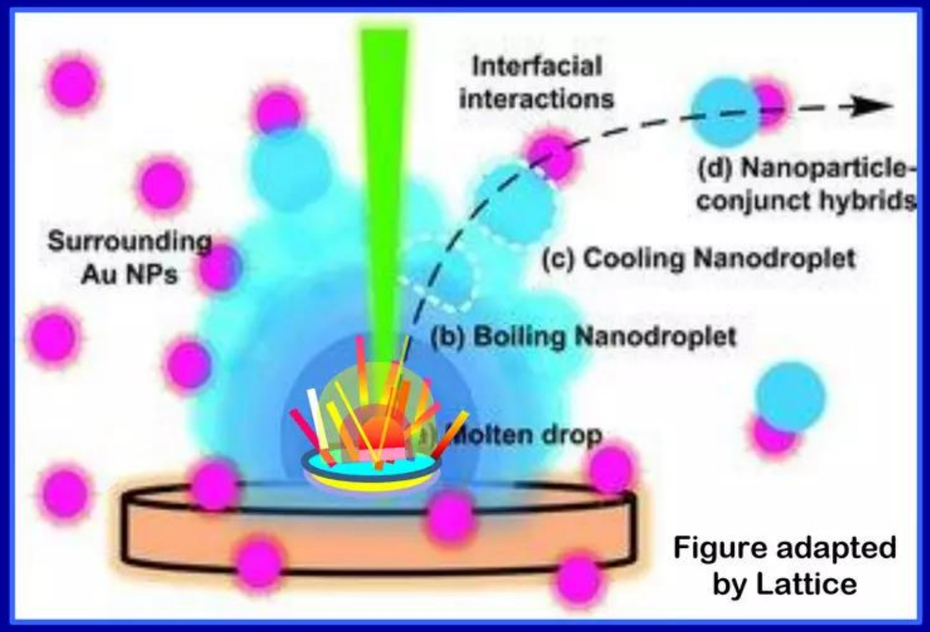


Figure adapted by Lattice

Lattice comment: U.S. Navy SPAWAR researchers observed acoustic events in parallel with thermal imaging of transient LENR hot spots on electrodes

Quoting directly: "The flashes observed in the IR experiments suggest 'mini-explosions' so we designed an experimental set-up to see if we could record these events using a piezoelectric sensor."

http://lenr-canr.org/acrobat/SzpakSpolarizedda.pdf

Polarized D^+/Pd–D_2O system: Hot spots and mini–explosions

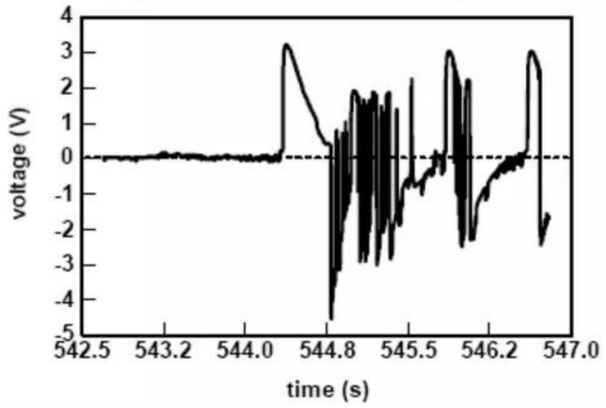
S. Szpak, P.A. Mosier–Boss, J. Dea and F. Gordon
Spawar Systems Center San Diego, San Diego, CA 92152–5001

Abstract

Two types of activities occurring within the polarized D^+/Pd–D_2O system, viz. the presence of localized heat sources (hot spots) and associated with them mini–explosions, are described. The "birth and death" of hot spots is monitored by IR imaging while the mini–explosions are displayed by the voltage spikes exhibited by a piezoelectric substrate onto which a Pd/D film was co–deposited. Processes leading to the formation of unstable domains as a precursor to the observed behavior is examined.

Piezoelectric Response to Pressure and Temperature vs Time

Expanded View with Reduced Amplification

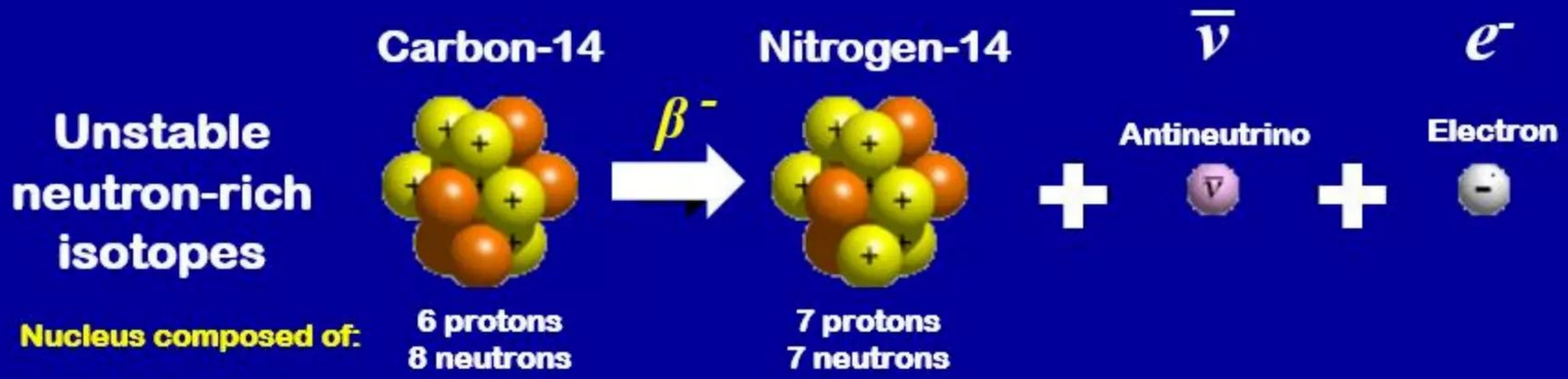


LENR transmutations involve beta-decay processes

Neutron captures commonly make unstable isotopes that beta decay

Gammas associated with neutron captures and beta decay converted to infrared

Example of beta-minus decay: one neutron spontaneously converts into a proton



Unstable radioactive Carbon-14 atom has been transmuted into stable Nitrogen-14

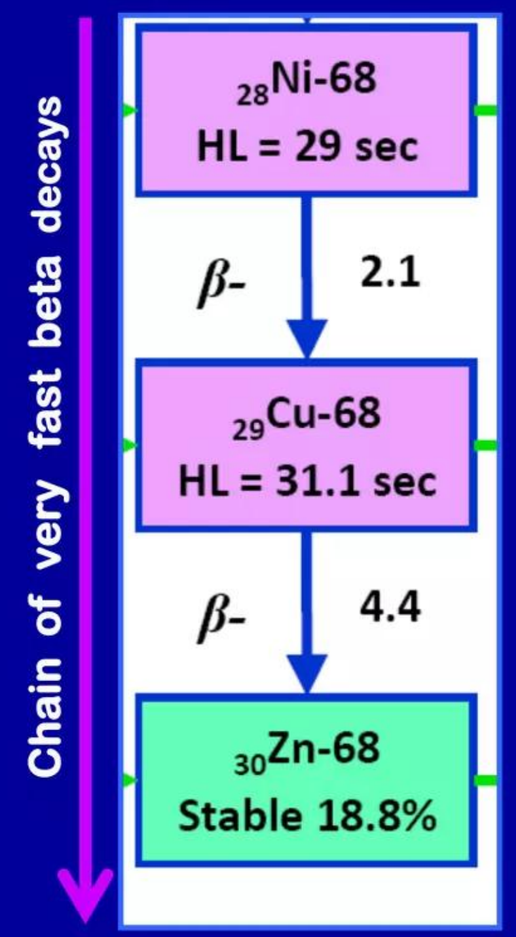
LENRs create near-zero amounts of radioactive waste

Differ greatly from nuclear fission and fusion processes in this regard

β and α particles not penetrating; are stopped by piece of paper or human skin

- ✓ Capture of ultra low energy (ULE) neutrons will produce build-up of local populations of unstable, very neutron-rich isotopes comprising intermediate transmutation products
- ✓ At some point during limited lifetimes of all LENR-active patch, almost all such isotopes present in it will quickly decay, mainly by series of very rapid β-decay cascades
- ✓ Depending on the half-lives (HL) of intermediate LENR products, ULE neutron captures plus 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 simple example of ^{68}Ni to right)
- ✓ β-decay cascades are reason why LENRs typically do not produce serious amounts of long-lived radioactive wastes

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

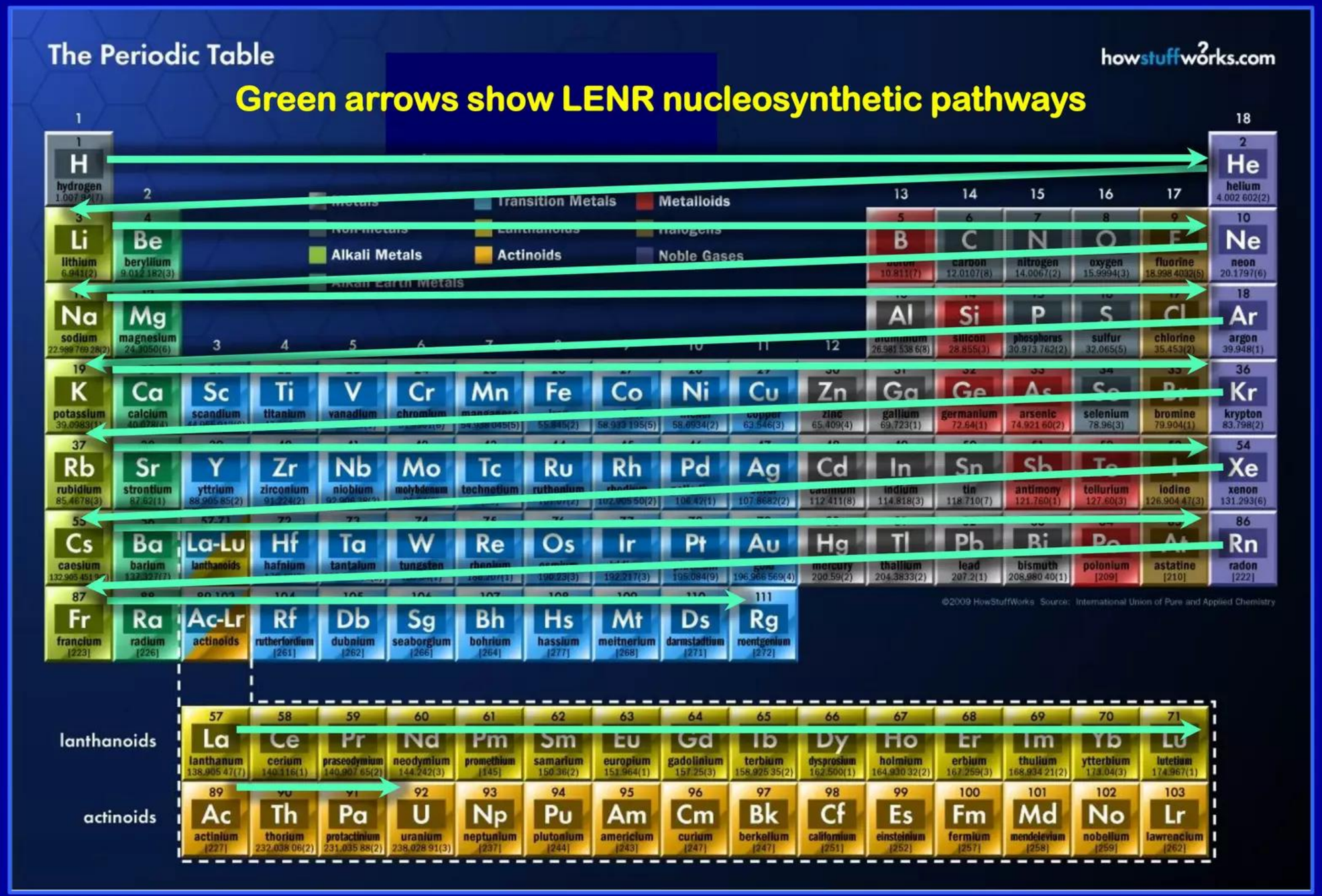


Decay energies in MeV to right of arrow

LENR transmutations go from Hydrogen to Uranium

Neutron captures and beta decays follow rows in the Periodic Table

Terrestrial nucleosynthesis produces heavier elements from lighter elements



LENRs are enabled by many-body collective effects

Stars, fission reactors, tokamaks and nuclear weapons not necessary

Unlike nuclear fusion reactions LENRs don't need high temperatures to operate

- ✓ SP electron mass-renormalization by collectively absorbing E-M energy directly from a local electric field allows a portion of the SP electrons sitting in a tiny LENR-active patch to possess enough additional mass-energy (>0.78 MeV) to cross the energetic threshold for reacting directly with local coherent protons or deuterons to make neutrons and neutrinos; SP electrons DO NOT have to be at high temps to do this = aikido physics

- ✓ Comparatively cool, collective many-body aikido field-energy process in condensed matter LENRs contrasts sharply with few-body taekwondo kinetic processes that occur in stellar, tokamak, *Z*-pinch, and ICF-target fusion plasmas where charged particles, e.g. d^+ and t^+, are heated-up to enormous temperatures so a small subset (high-energy tail of the Maxwellian distribution of particle energies) of them that strike each other head-on have enough kinetic energy to surmount the Coulomb energetic barrier (like charges repel each other) to nuclear fusion reactions

Physics martial arts: hot taekwondo versus cool aikido

$e^- + p^+$ in stars needs charged-particle taekwondo at enormous temps

LENRs use collective aikido: do not need high temp taekwondo to trigger $e^- + p^+$

Crab nebula: remnant of a supernova explosion that was observed by many Chinese astronomers in 1054 A.D.

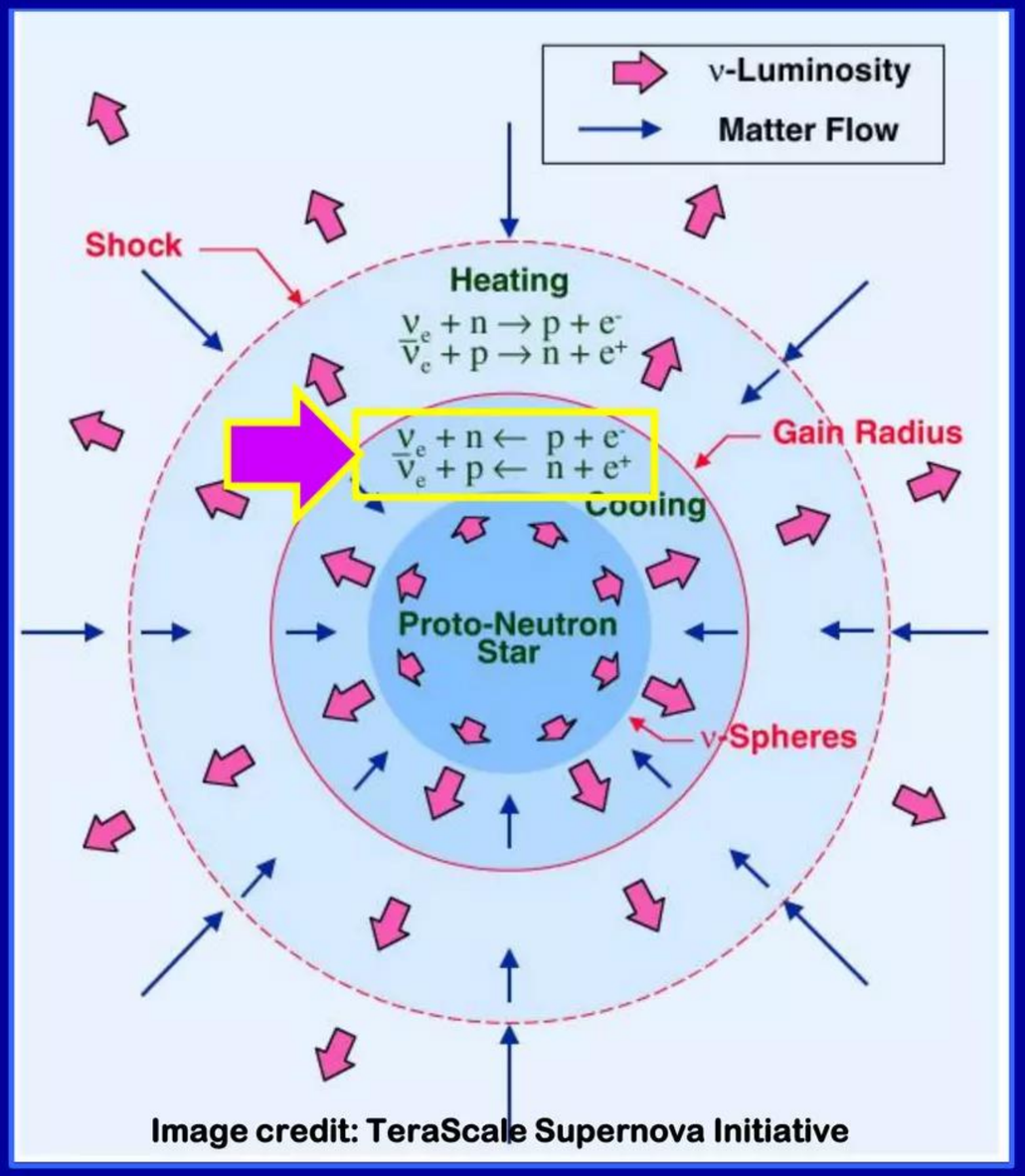
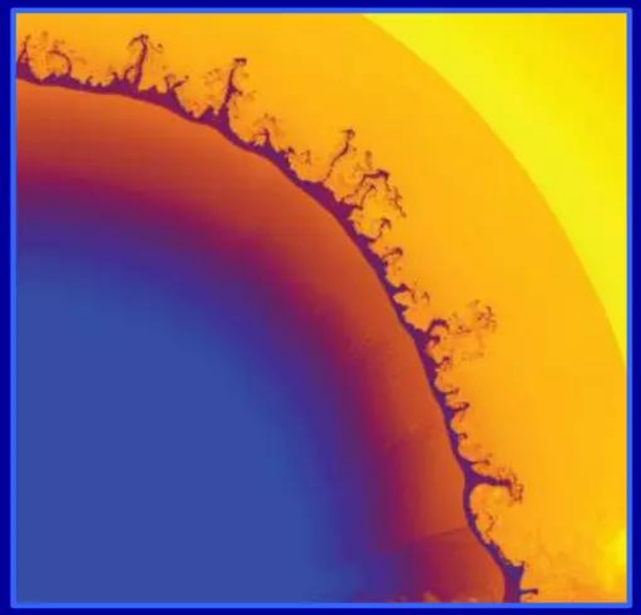


Image credit: TeraScale Supernova Initiative



"One series of NIF experiments is studying hydrodynamic instabilities in supernovae. This simulation, created by team member Tomasz Plewa from Florida State University, shows Rayleigh-Taylor instability growth during a supernova in a red supergiant star."

$e + p$ reaction occurs from microcosm to the macrocosm

LENRs occur in organisms, rocky/gas-giant planets, nebulae, and stars

Age-old belief that nucleosynthesis doesn't occur in Earth environs is erroneous

	Length Scale	Type of System	Electromagnetic Regime	Collective LENR Phenomena	Comment
Totally benign	Nanometers to microns	Certain earthly bacteria and some species of fungi	Very short-range electric or magnetic fields	Minimal heat, transmutations, very high level of gamma suppression, some β emissions	Obtain unavailable trace elements; survive deadly gamma/X-ray radiation
	Nanometers to microns	Entangled Hydrogen isotopes on metallic surfaces, at interfaces, or on aromatic rings	Very high, short-range electric fields on solid substrates	Heat, transmutations, high level of gamma suppression, fluxes of energetic charged particles	This regime is useful for small-scale commercial power generation
Commercial power systems would probably need some type of shielding	Microns to centimeters	Piezoelectric or pyroelectric effects in brittle solids	Very high, short-range electric fields on surfaces	Transmutations, reduced gamma suppression, heat, some energetic neutrons & +/-particles	Occurs in laboratory devices as well as out in Nature
	Centimeters to Many Meters	Exploding wires, planetary lightning	Dusty plasmas: mixed high-currents and/or high organized magnetic fields	Much heat, transmutations, leakier gamma suppression, X-rays to 10 keV, larger fluxes of energetic neutrons & +/-particles	This regime is useful for large-scale commercial power generation
	Many Meters to Kilometers	Outer layers and atmospheres of stars (flux tubes)	Dusty plasmas: high mega-currents and very large-scale, highly organized magnetic fields	Even more heat, transmutations, very large fluxes of energetic neutrons & +/-particles (to GeVs) & X-rays and gammas	Solves mysteries of heating of solar corona and radioactive isotopes in some stellar atmospheres
	Up to several AUs (earth-to-sun distance)	Active galactic nuclei in vicinity of compact, massive objects (black holes)		Extremely energetic +/- particles and neutrons (GeVs), gamma-ray bursts (GRBs) and ultra-high energy cosmic rays (TeVs)	Solves several unexplained astronomical mysteries

$e + p$ reaction occurs from microcosm to the macrocosm

LENRs occur in organisms, rocky/gas-giant planets, nebulae, and stars

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 ultralow energy neutron catalyzed reactions

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

Low to medium electric and/or ion currents

Neutron production, capture, release energy, and transmutation products

- Microorganisms – biological transmutations by certain types of earthly bacteria & fungi
- Pressure gradients across membranes – e.g., Iwamura, Li, & Arata-Zhang - 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, etc. - liquid or gas phase

High currents; electrons and/or ions

- RF-triggered dusty plasmas - gas phase
- Current-driven dusty plasmas - gas phase
- Vacuum diodes – e.g. Proton-21, Kiev, Ukraine, Sandia NL (US) in 1970s - gas phase
- Exploding wires – e.g., Wendt & Irion, Chicago 1922; Z-pinch, Sandia NL - gas phase
- Piezoelectric and pyroelectric processes in solid-state materials – Carpinteri, Naranjo
- Magnetic flux compression generators, e.g. US (LANL), Russia
- Lightning (terrestrial, planetary, nebular), especially in dusty environments – e.g., Dwyer
- ULMN-catalyzed subcritical fission reactors (<<< nuclear waste) - reprocess old wastes

Higher fluxes of neutrons

Scales-up to very large length scales

Wide range of magnetic field strengths

Mega-scale currents

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

- 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

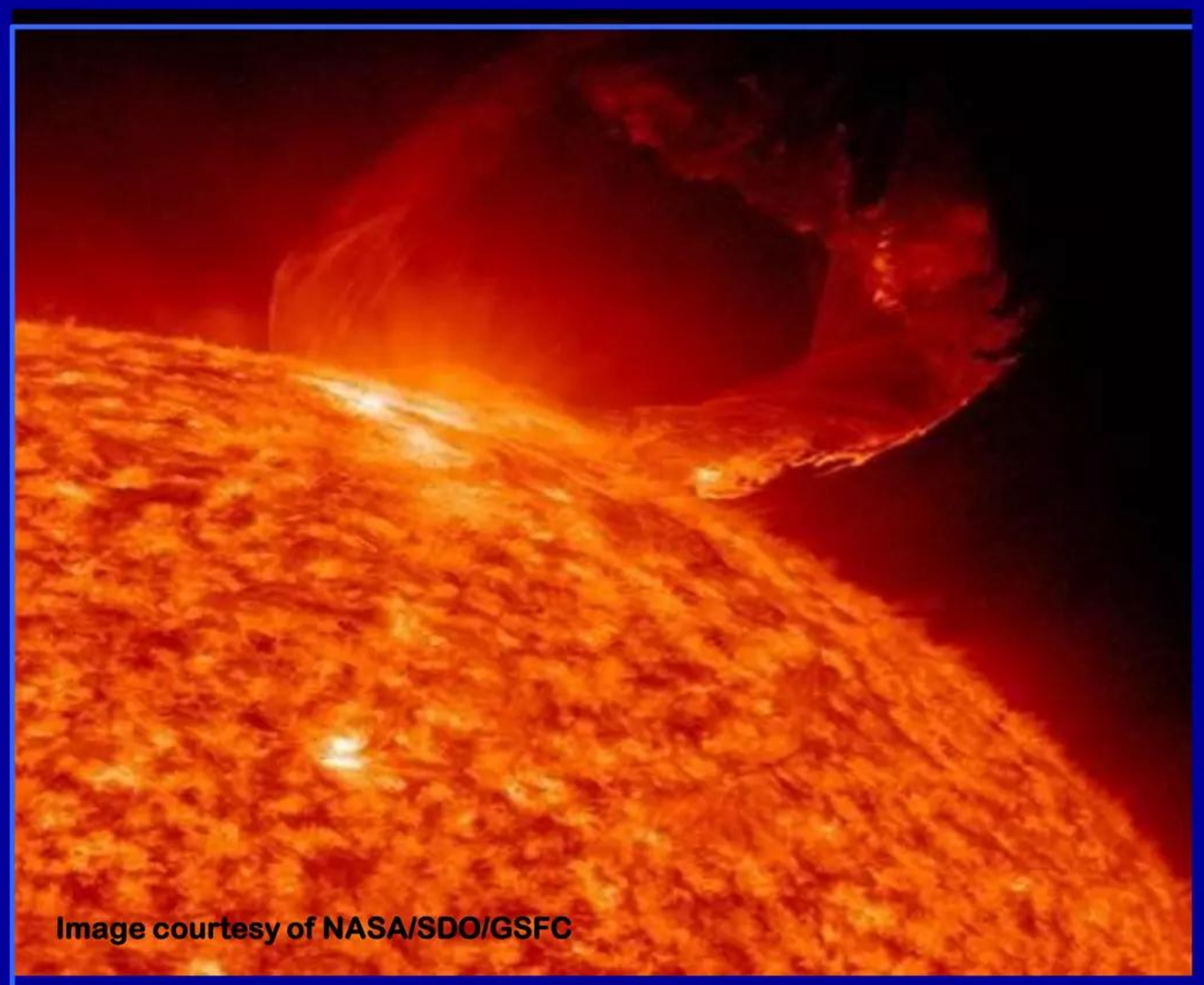
Stars, supernovae, and fission reactors are optional

Widom-Larsen theory suggests nucleosynthesis may be common

While natural LENR reaction rates low, effects accumulate over geological time

Data and theory indicate that LENRs could occur in a wide variety of natural environments

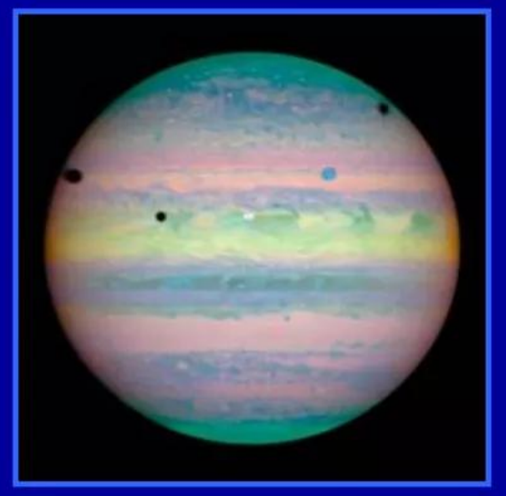
Lightning is like exploding wires



March 19, 2011 – image of major eruption on the surface of the Sun
LENRs can also occur in the photosphere, flux tubes, and the corona

Very dusty Eagle nebula

Earth: LENRs in many places



Jupiter perhaps not 'failed star'

Hydrogen (protons) readily available within Earth's crust

Crushed andesite essentially produced ~5,000 cm^3 of H_2 per m^3 of rock

"Hydrogen in rocks: an energy source for deep microbial communities"
F. Freund *et al.*, *Astrobiology* 2 pp. 83 - 92 (2002)
http://online.liebertpub.com/doi/abs/10.1089/153110702753621367

Excerpting from abstract: "To survive in deep subsurface environments, lithotrophic microbial communities require a sustainable energy source such as hydrogen … A more reliable and potentially more voluminous H_2 source exists in nominally anhydrous minerals of igneous and metamorphic rocks. Our experimental results indicate that H_2 molecules can be derived from small amounts of H_2O dissolved in minerals in the form of hydroxyl, OH, or $O_3Si–OH$, whenever such minerals crystallized are in an H_2O-laden environment. Two types of experiments were conducted. Single crystal fracture experiments indicated that hydroxyl pairs undergo an *in situ* redox conversion to H_2 molecules plus peroxy links, $O_3Si/OO\backslash SiO_3$. While the peroxy links became part of the mineral structure, the H_2 molecules diffused out of the freshly fractured mineral surfaces. If such a mechanism occurred in natural settings, the entire rock column would become a volume source of H_2. Crushing experiments to facilitate the out-diffusion of H_2 were conducted with common crustal igneous rocks such as granite, andesite, and labradorite. At least 70 nmol of H_2/g diffused out of coarsely crushed andesite, equivalent at standard pressure and temperature to 5,000 cm^3 of H_2/m^3 of rock. In the water-saturated, biologically relevant upper portion of the rock column, the diffusion of H_2 out of the minerals will be buffered by H_2 saturation of the intergranular water film."

Conceptual paradigm shift: terrestrial nucleosynthesis

W-L theory predicts occurring at low rates in planetary environments

Examples: $e + p$ can occur in lightning bolts and during piezoelectric fracturing

- ✓ Theoretically predicted production of low-energy neutrons in lightning via the Widom-Larsen $e + p$ mechanism was effectively confirmed by Gurevich *et al.* (*Phys. Rev. Lett.* 2012); please see following document:

> "New Russian data supports Widom-Larsen theory neutron production in lightning" L. Larsen, Lattice Energy LLC, April 4, 2012 [73 slides]
> http://www.slideshare.net/lewisglarsen/lattice-energy-llcnew-russian-data-supports-wlt-neutron-production-in-lightningapril-4-2012

- ✓ Widom *et al.* (2012) have theoretically shown how neutron production via the W-L $e + p$ mechanism can occur via piezoelectric fields created during brittle fractures of appropriate types of rocks such as granites:

> "Neutron production from the fracture of piezoelectric rocks"
> A. Widom, J. Swain, and Y. Srivastava
> *Jour. of Phys. G: Nuclear and Particle Physics* 40 pp. 015006-14 (2012)
> http://iopscience.iop.org/0954-3899/40/1/015006/article

Conceptual paradigm shift: terrestrial nucleosynthesis

What would one expect to observe if LENRs occurring in Earth's crust?

If LENRs were occurring in the Earth's crust, especially in the uppermost three meters of rocks or soils, one would very likely expect to observe and measure:

- ✓ **Enhancement of surface latent heat fluxes (SLHF)** from micron-scale nuclear energy releases, especially on shorter timescales that rule-out conduction of prosaic geothermal heat coming from deeper in the crust
- ✓ **Concomitant increases in local fluxes of non-cosmogenic thermal neutrons**
- ✓ **Occurrence of odd perturbations in measured gamma radiation;** it could be either anomalous increases or - much more likely - inexplicable decreases occuring on timescales far too short to be reasonably explained by normal variation in external cosmogenic radiation sources or local α or β^- decays
- ✓ **Unusually high production of ionized particles and energetic electrons close to Earth's surface** in absence of local lightning or thunderstorm activity
- ✓ **Anomalous isotopic shifts in stable elements** that cannot reasonably be explained by operation of ordinary chemical fractionation processes
- ✓ Radon: **anomalously fast increases (nano-fracking of rocks by LENR-active sites releases trapped Rn gas) or decreases (Rn captures neutrons and β decays into another element) in measured concentrations near Earth surface**

Conceptual paradigm shift: terrestrial nucleosynthesis

If neutron production via the $e + p$ reaction occurs in Earth's environs

Then what types of physical effects would we expect to observe and measure?

- ✓ **Note #1:** vast majority of ultralow energy LENR neutrons produced will be captured locally before they have had enough time to thermalize (which requires 0.1 to 0.2 μsec, i.e. 10^{-4} sec. per S. Lamoreaux); however, a very small percentage of them will be able to reach thermal energies and would then be detectable as free neutrons (0.025 eV traveling at 2,200 m/sec with half-life ~13 minutes); some of these LENR neutrons will further become epithermal

- ✓ **Note #2:** piezoelectric $e + p$ neutron production mechanism of Widom *et al.* (2012) would likely operate in rocks and soils where appropriate types of mineral grains (e.g., quartz) are undergoing brittle fracture from mechanical forces; would likely produce mixtures of fast (0.1 to 10 MeV) neutrons and slow neutrons (~1 keV - mainly created by fast neutrons scattering off atoms)

- ✓ **Note #3:** for LENR $e + p$ neutron production involving Q-M entangled many-body 'patches' of Hydrogenous atoms, many unreacted heavy electrons will directly convert locally produced or incoming ambient external gammas (in energy range of ~0.5 - 1.0 up through ~10 - 11 MeV) directly into very benign infrared (IR) photons. Presence of populations of heavy-mass electrons could be detected as excess IR emissions or odd perturbations in gamma radiation

Conceptual paradigm shift: terrestrial nucleosynthesis

If neutron production via the $e + p$ reaction occurs in Earth's environs

Then what types of physical effects would we expect to observe and measure?

- ✓ **Note #4:** isotope measurements that could represent signatures of LENR activity for a given element present in a sample (that are clearly not the result of external contamination) include significant variances from widely accepted values for natural Earthly isotopic abundances that --- for one reason or another --- cannot be reasonably explained by invoking a prosaic chemical fractionation process, whether it be mass-dependent or mass-independent. Under many circumstances, LENR transmutations readily mimic fractionation

- ✓ **Note #5:** presence of very anomalous isotopes in a given sample (measured with accurate mass spectroscopy techniques) that are not typical "cosmogenic nuclides" produced (directly or indirectly) by a cosmic ray spallation process in near-surface materials; these are used as markers in surface exposure dating schemes and include: ^{26}Al, ^{37}Ar, ^{39}Ar, ^{41}Ar, ^{7}Be, ^{10}Be, ^{11}C, ^{14}C, ^{41}Ca, ^{34m}Cl, ^{36}Cl, ^{38}Cl, ^{39}Cl, ^{18}F, ^{3}H (tritium), ^{129}I, ^{81}Kr, ^{28}Mg, ^{22}Na, ^{24}Na, ^{32}P, ^{35}S, ^{31}Si, and ^{32}Si

- ✓ **Note #6:** while very high-energy cosmic ray spallation particles can penetrate terrestrial materials down to as much as 3 meters beneath the Earth's surface, any energetic gamma and/or neutron radiation originating locally are heavily attenuated at depth of just 1 meter and almost entirely within 2 meters: thus, non-cosmogenic neutron or gamma radiation coming from a surface is local

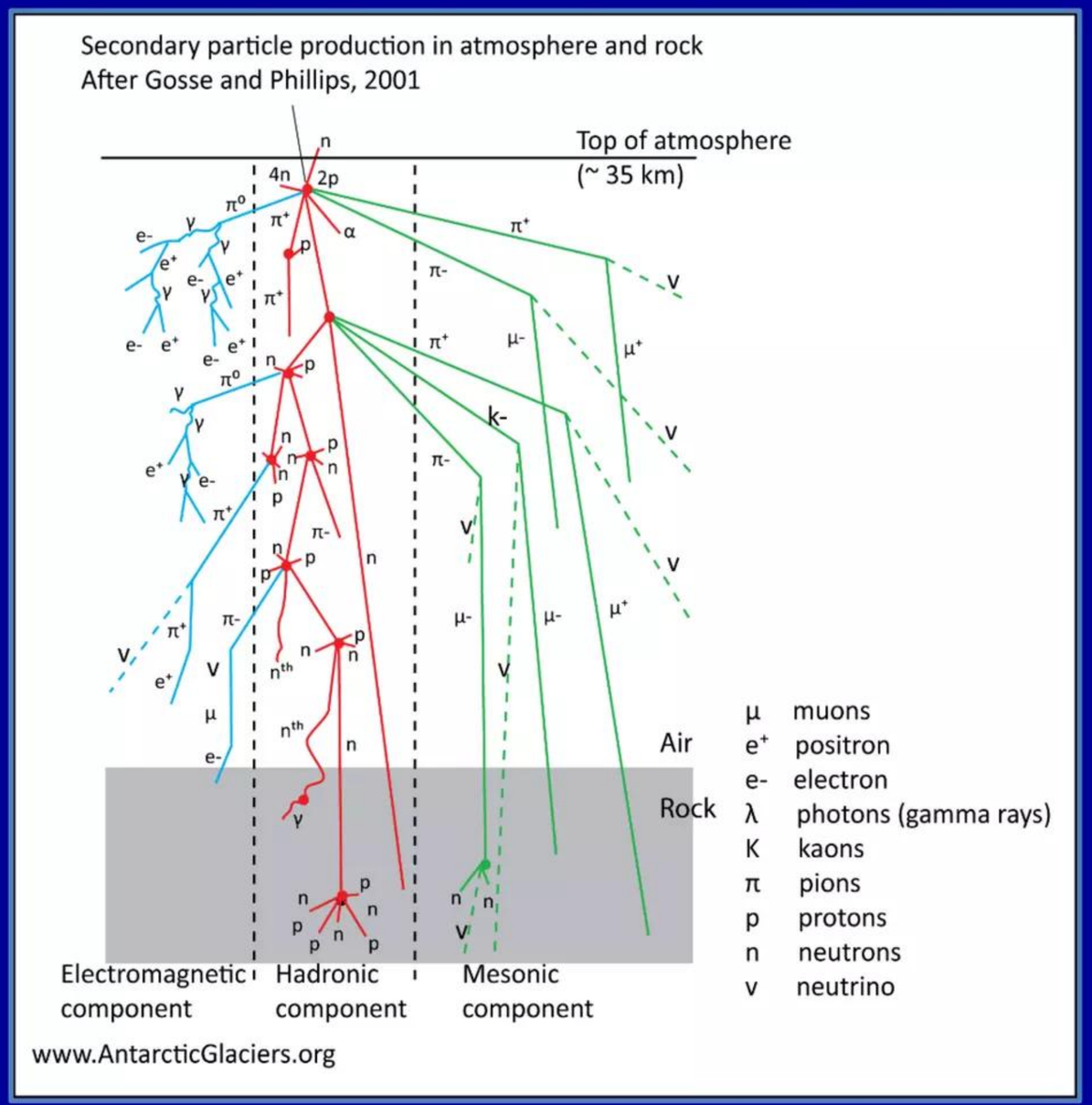
Conceptual paradigm shift: terrestrial nucleosynthesis

If neutron production via the $e + p$ reaction occurs in Earth's environs

Then what types of physical effects would we expect to observe and measure?

- ✓ **Note #7:** over short time-spans of minutes to hours, neutron and gamma radiation produced by cosmic ray spallation processes should be ~constant; substantial variation in fluxes over such short timescales would be indicative of local causes for such variability; i.e., potentially caused by LENRs
- ✓ **Note #8:** changes in neutron and gamma radiation temporally well-correlated with seismic activity are unlikely to be cosmogenic in origin; again, might be caused by LENRs
- ✓ **Note #9:** except for Actinides, vast majority of unstable isotopes found in Earth's crust undergo alpha or beta decays; do not emit neutrons

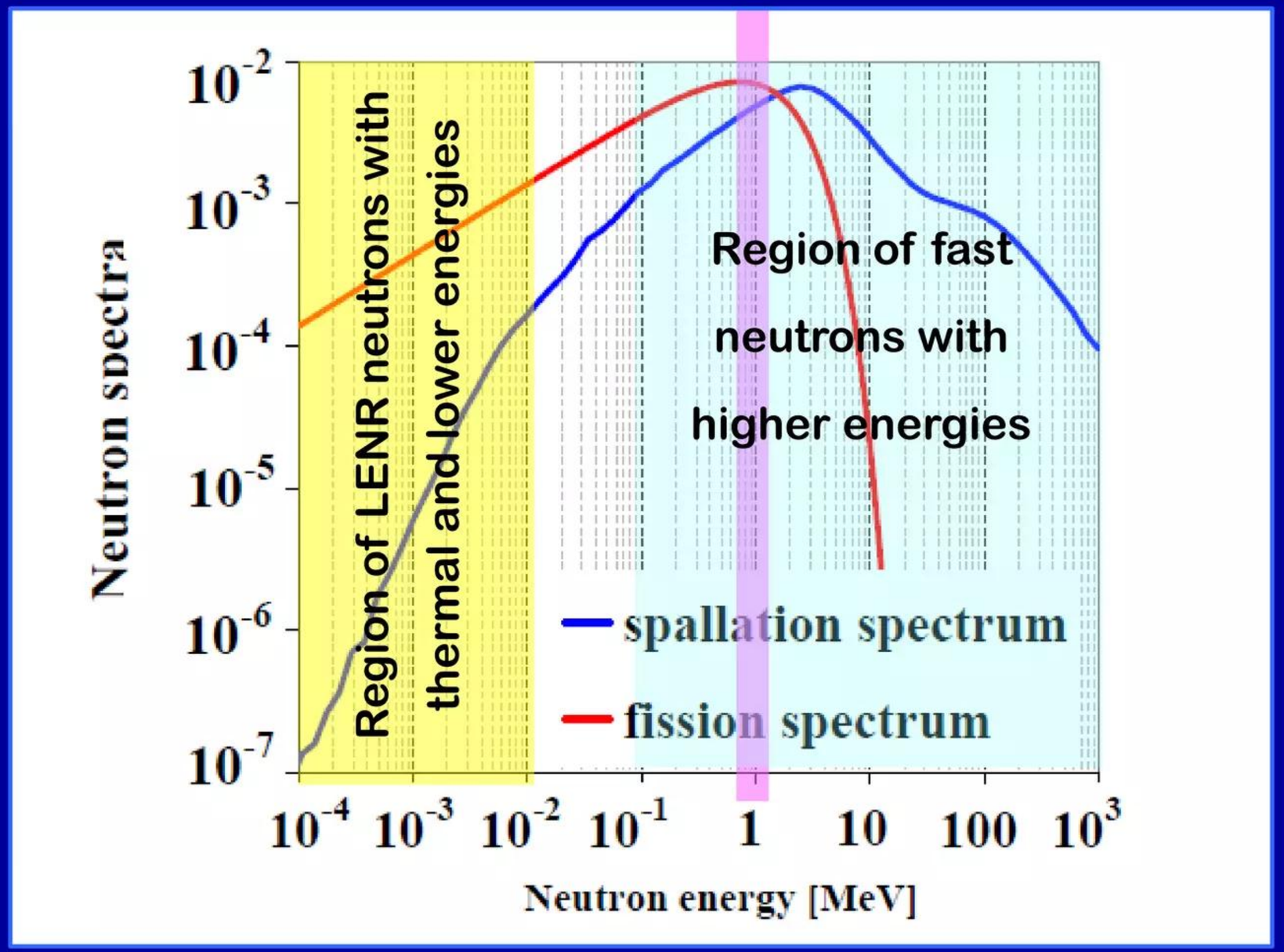
Particles produced in cosmogenic spallation



Conceptual paradigm shift: terrestrial nucleosynthesis

Ultralow energy neutrons are produced in $e + p$ with entangled protons

Spectral peaks for cosmogenic spallation and fission neutrons located at ~1 MeV



Conceptual paradigm shift: terrestrial nucleosynthesis

New type of crustal energy transfer besides acoustic seismic process

Quite mobile *p*-hole positive charge carriers produced in strained crustal rocks

- ✓ Friedemann Freund of NASA-Ames has discovered a new type of energy transfer mechanism that operates within Earth's solid crust and involves collective many-body, delocalized positive quasiparticles called *p*-holes
- ✓ *p*-holes are created by conversion of mechanical stress/strain energy into electronic energy in the form of highly mobile, positive charge carriers that propagate rapidly through rocks at phase velocities as high as 200 m/sec
- ✓ Freund *p*-holes rapidly transfer mobile electronic energy to remote locations elsewhere in the Earth's crust physically distant from initial points of origin: transport over meters has been measured in the laboratory; best field data indicates transport distance in Earth's crust may extend to tens of kilometers
- ✓ Freund's published work shows that many common types of rocks can serve as reasonably effective conductors for *p*-holes, allowing large positive hole currents (along with 'mirror' electron currents) to flow fast over substantial distances through the Earth's upper and middle crust. This new way of thinking about geophysics represents a major conceptual paradigm-shift and flies in the face of naive conventional wisdom, which considers most rocks to simply be immutable electrical insulators. We now know that is not the case

Conceptual paradigm shift: terrestrial nucleosynthesis

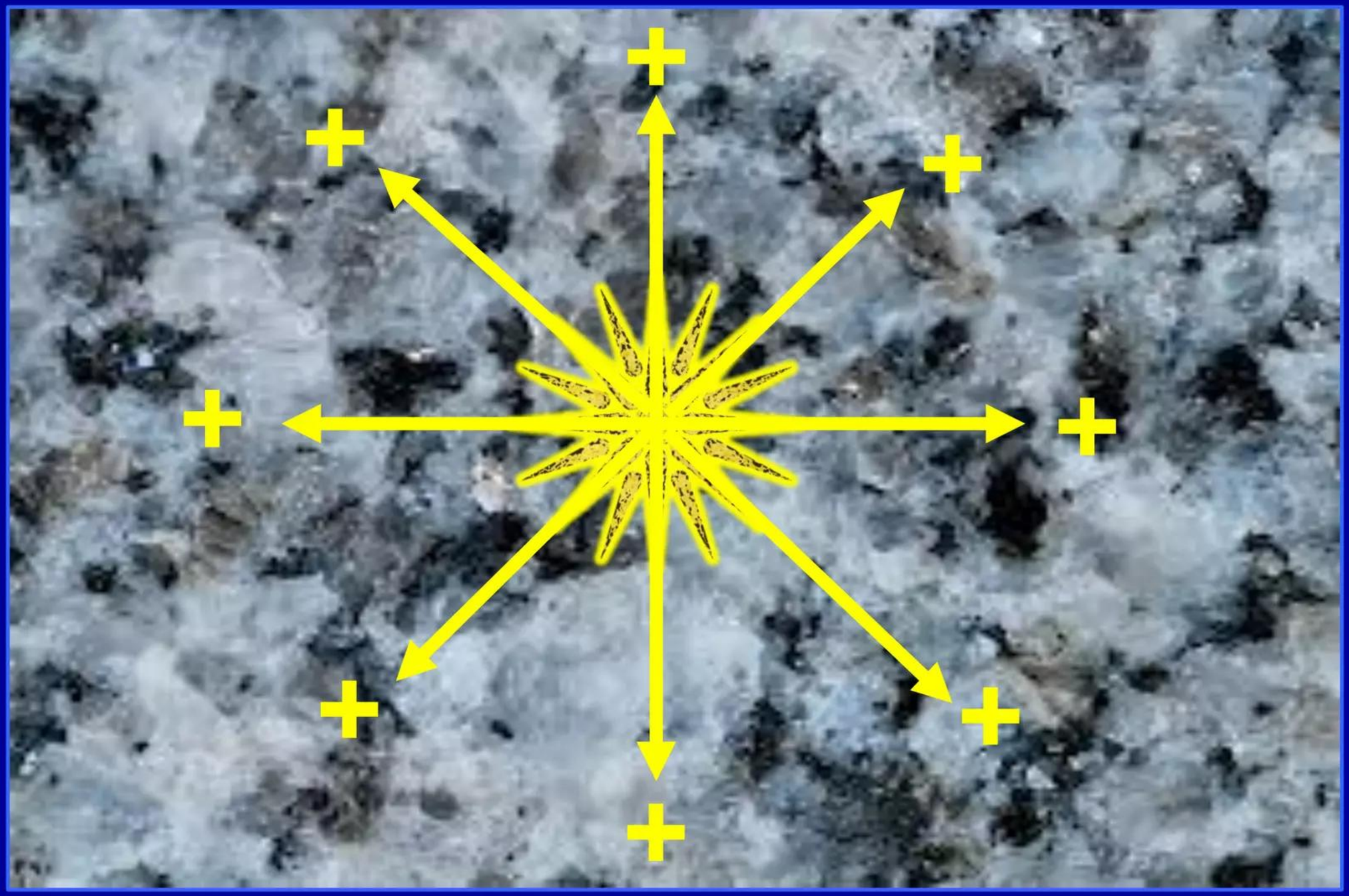
LENRs need input energy: can be provided by *p*-hole charge carriers

Hotspot LENR sites can weaken rocks locally and facilitate increased seismicity

- ✓ ***p*-holes produced dynamically by non-equilibrium changes in stress/strain tensors and/or by rapid rock heating and can exist in many common rock types except for marbles for reasons consistent with Freund's theory; can successfully propagate way beyond boundaries of subvolumes in which they are initially created; readily cross mineral grain boundaries in rocks with limited scattering and energy losses**
- ✓ **When *p*-holes deposit their electronic energy at mineral interfaces having surface plasmons, where collectively oscillating, quantum mechanically entangled patches of hydrogen atoms (protons or deuterons) are also present, it is very likely that under the right set of conditions, rapid injection of nonequilibrium pulses of energy from inbound *p*-holes could lead to creation of μ-scale nuclear-strength (> 10^{11} V/m) electric fields, which would cause effective SP electron masses to increase, thus enabling production of neutrons via an electroweak $e + p$ reaction**
- ✓ **With external energy input provided by *p*-holes, LENRs can transmute elements in micron-scale regions on surfaces and at interfaces in the Earth's crust. Existing for not more than 300 - 400 nanoseconds LENR-active sites can easily reach local temperatures as high as 4,000 - 6,000° K (hotspots), melting nearby materials and creating intense local ionization. Like *p*-holes, LENR-active sites can weaken rocks locally and facilitate increased seismicity if density of hotspot sites is high enough**

Mechanically strained rocks create *p*-hole quasiparticles

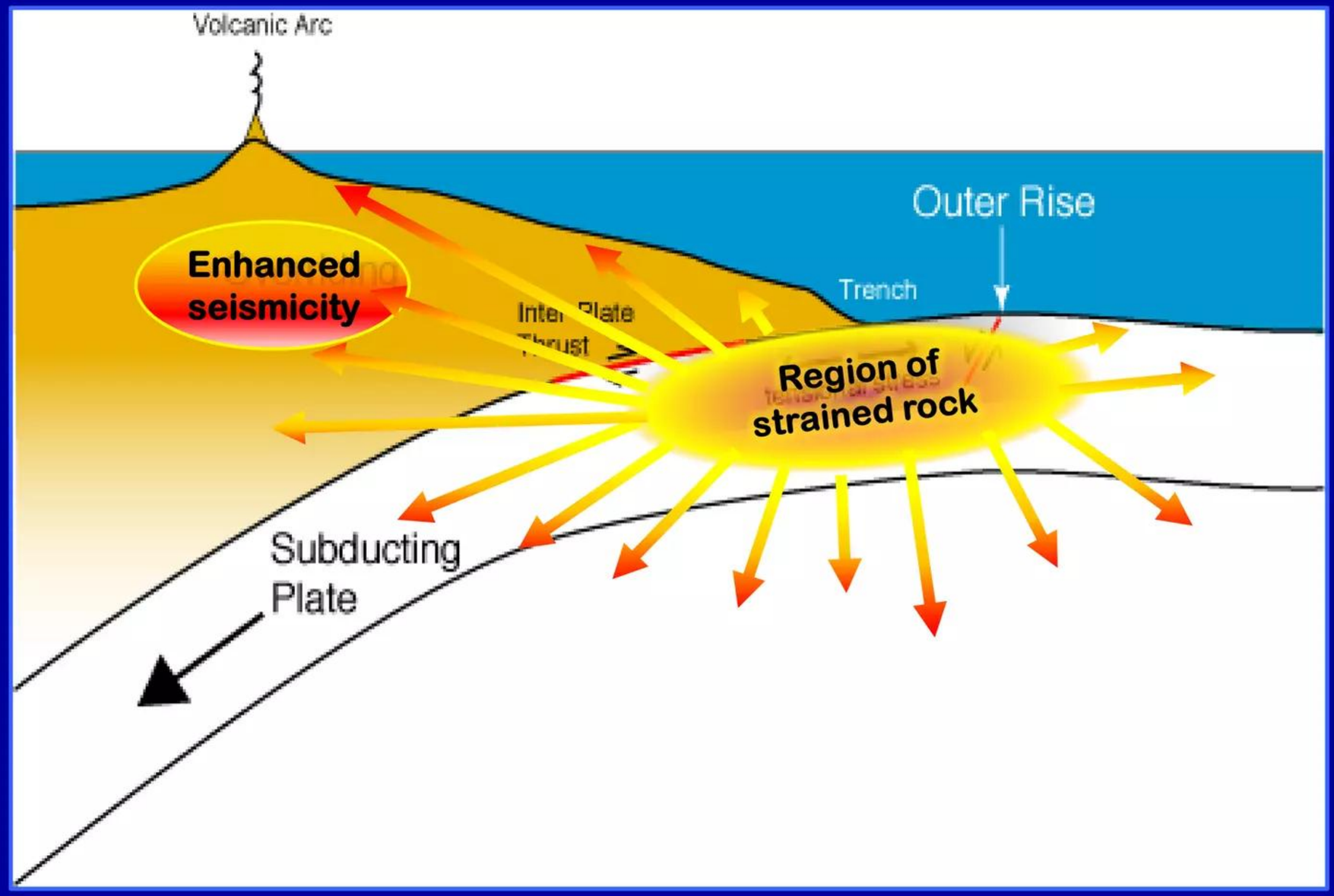
Mobile + charge-carriers propagate as far as kilometers and dissipate



Mechanically strained rocks create *p*-hole quasiparticles

‘Swarms’ of *p*-holes propagate outward from regions of stressed rocks

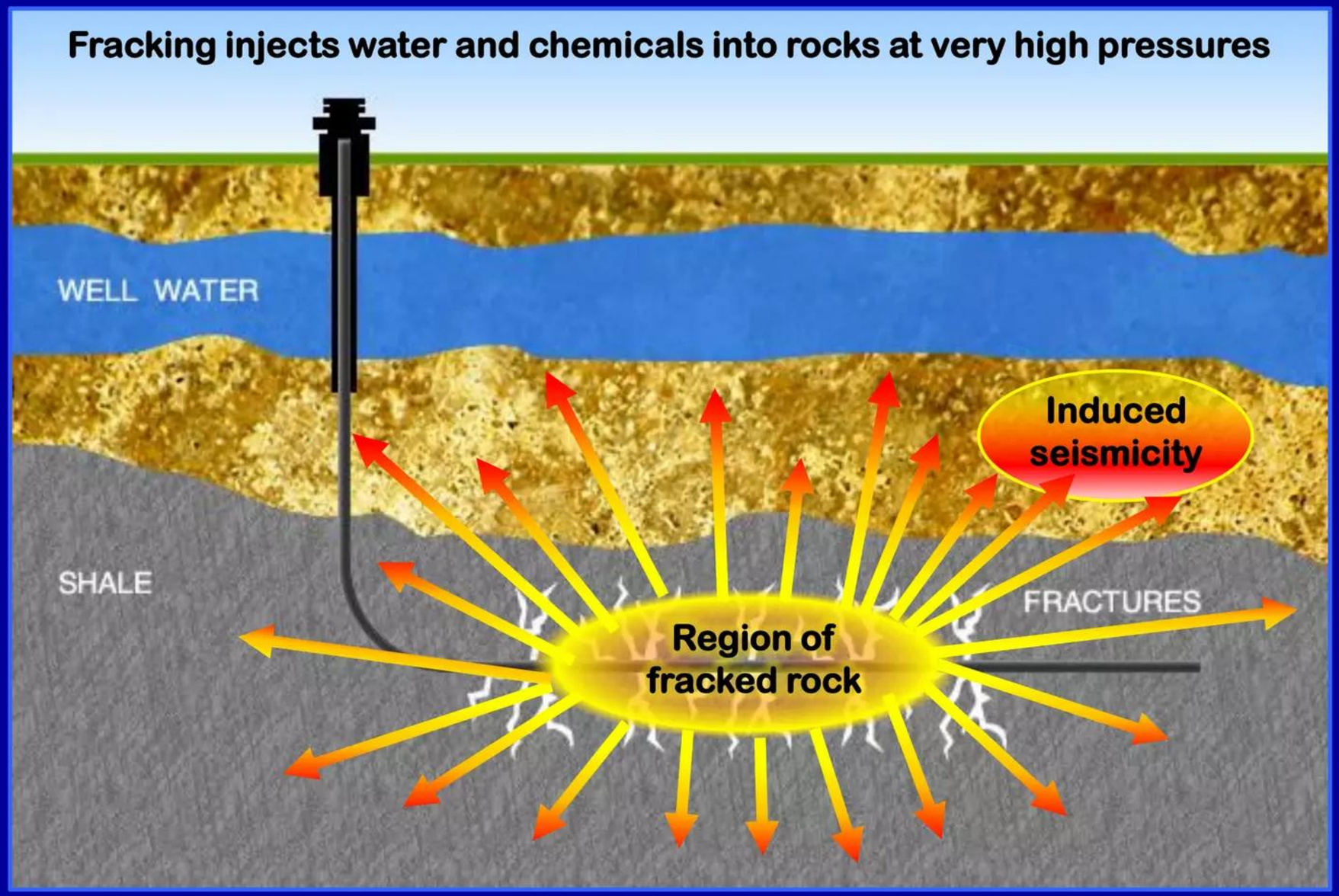
Deposit their electronic energy at distant sites which can locally weaken rocks



Mechanically strained rocks create *p*-hole quasiparticles

'Swarm' of *p*-holes will propagate outward from zones of fracked rocks

Deposit electronic energy at distant locations which can induce local seismicity



Friedemann Freund discovered *p*-holes > 20 years ago

Has since further characterized and measured these charge carriers

Detailed physics not yet worked-out: likely collective many-body quasiparticles

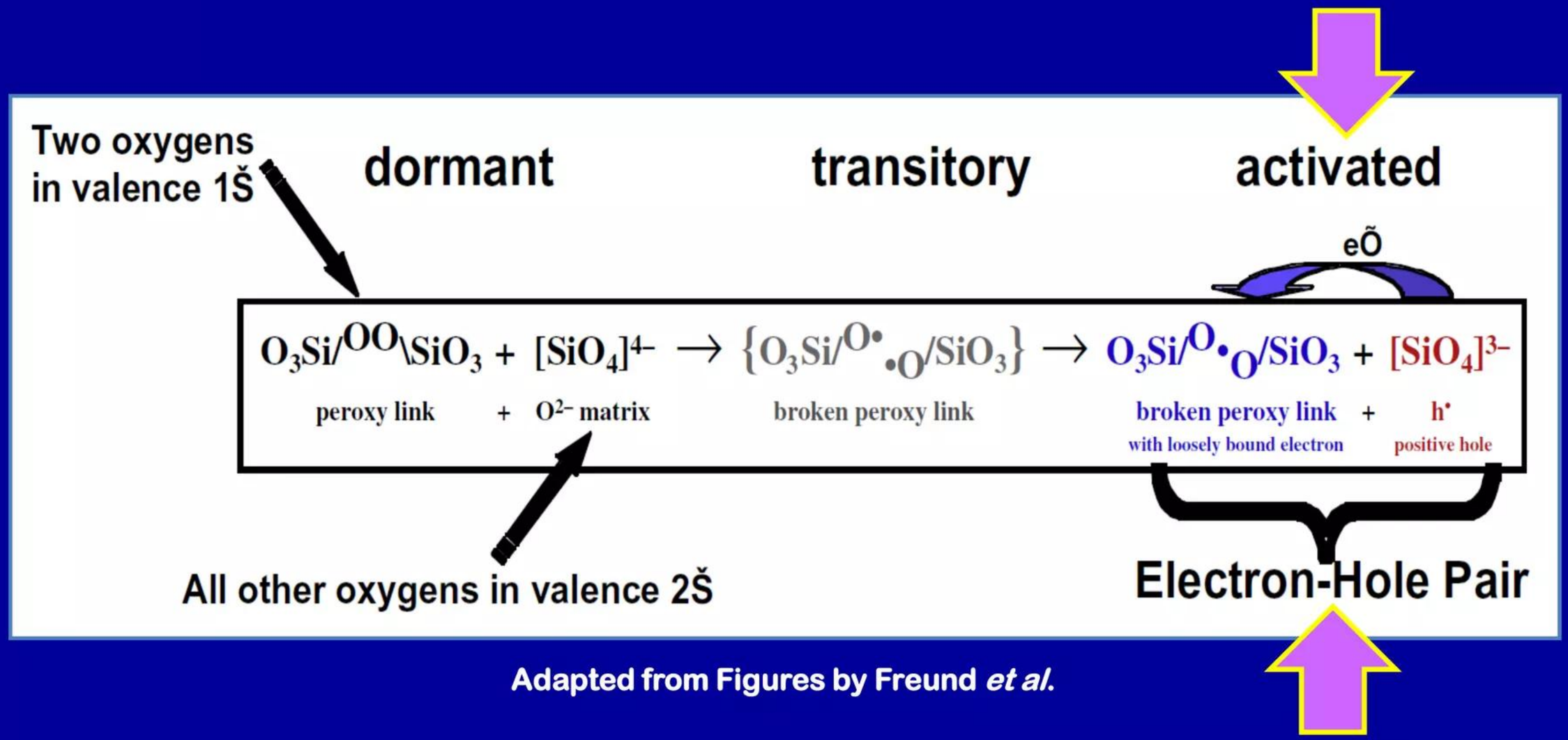
"Pre-earthquake signals: Underlying physical processes"
F. Freund, *Journal of Asian Earth Science* 41 pp. 383 - 400 (2011)
http://www.researchgate.net/publication/232411845_Pre-earthquake_signals_Underlying_physical_processes

- ✓ First discovered by Freund, and noting that detailed physics of *p*-holes has not yet been worked-out, they are likely to be some type of many-body, collective electronic quasiparticle that propagates as a mobile carrier of positive charge thru wide variety of common crustal rocks (except marbles) and wet or dry soils
- ✓ Unpublished experiments conducted by Freund which generated *p*-holes in water ice strongly suggest quantum entanglement amongst components of *p*-holes may also be key feature; see work of Chatzidimitriou-Dreismann, Tech. Univ. of Berlin
- ✓ Strain-induced creation of *p*-holes occurs at *extremely low* activation thresholds
- ✓ Propagate at phase velocities substantially slower than seismic P- and S-waves
- ✓ *p*-holes can transfer electronic energy thru rocks for meters in lab experiments and for multi-kilometer distances in the Earth's crust before losing their integrity
- ✓ Can release their energy as high local electric fields when they finally dissipate

Mechanical breaking of peroxy bonds creates *p*-holes

Chemical bond energy converted into mobile positive charge carriers

Energetic threshold for peroxy cleavage *very* low: handling rocks creates p-holes

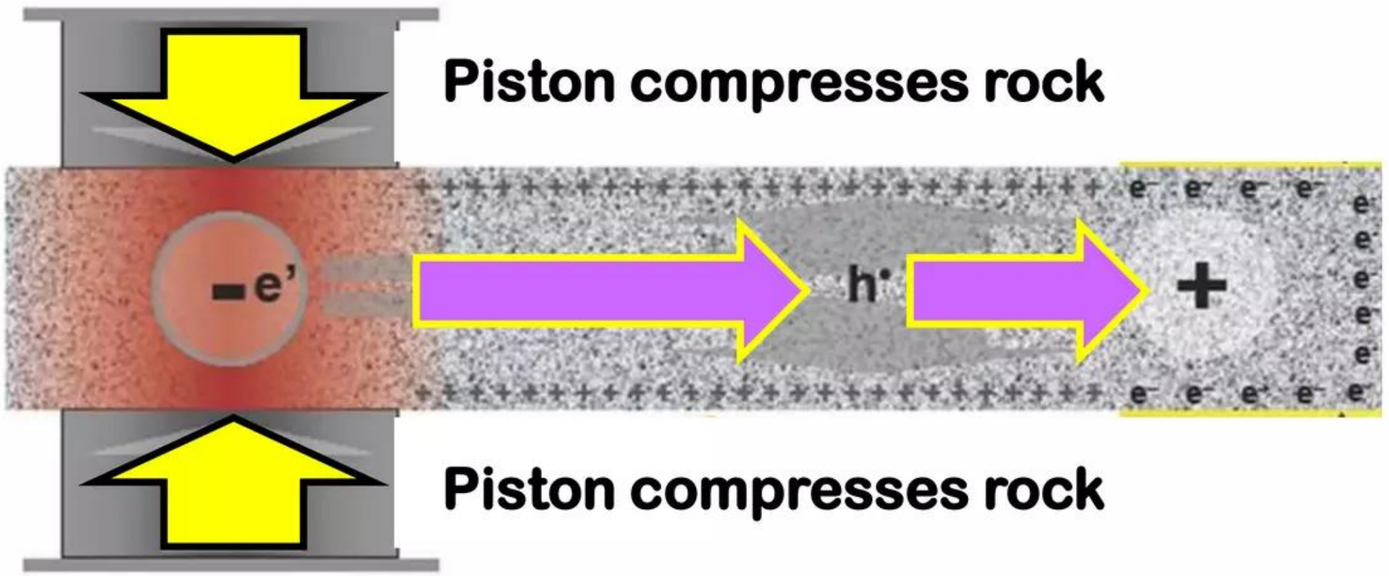


Adapted from Figures by Freund *et al.*

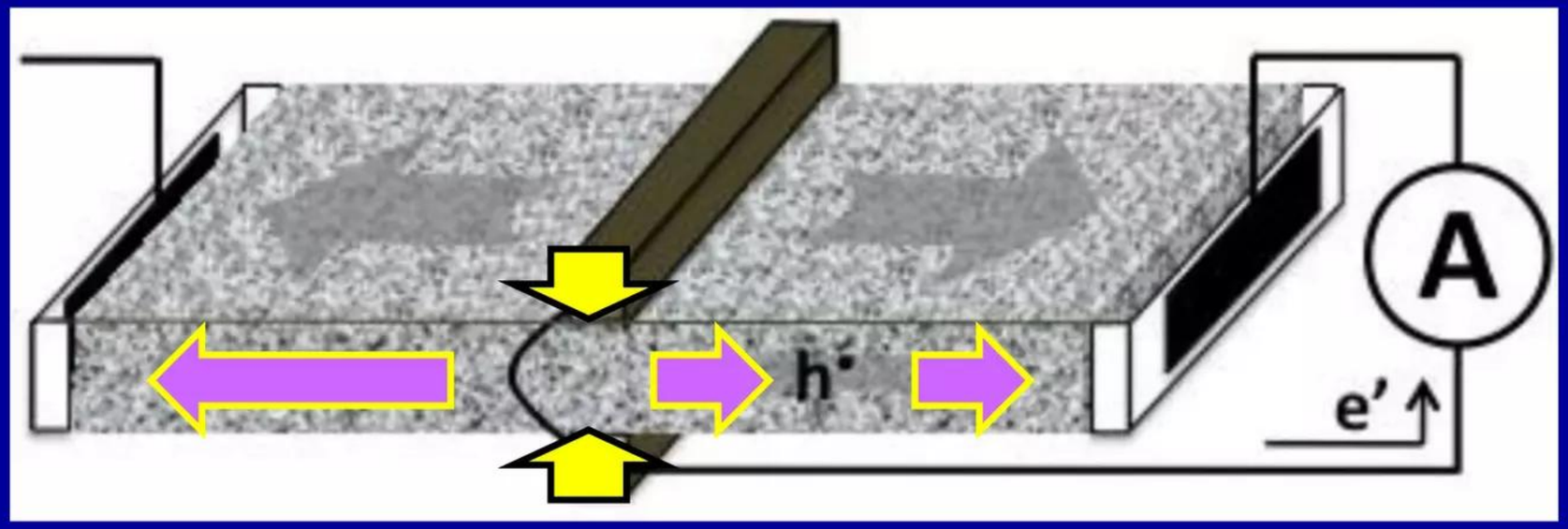
p-holes are created in controlled laboratory experiments

Compressed rocks generate mobile positively charged quasiparticles

Positive polarity emerges on distant surface after propagation thru sample rocks



Positive polarity measured on opposite surface signifies arrival of *p*-hole 'swarms'



Adapted from Figures by Freund *et al.*

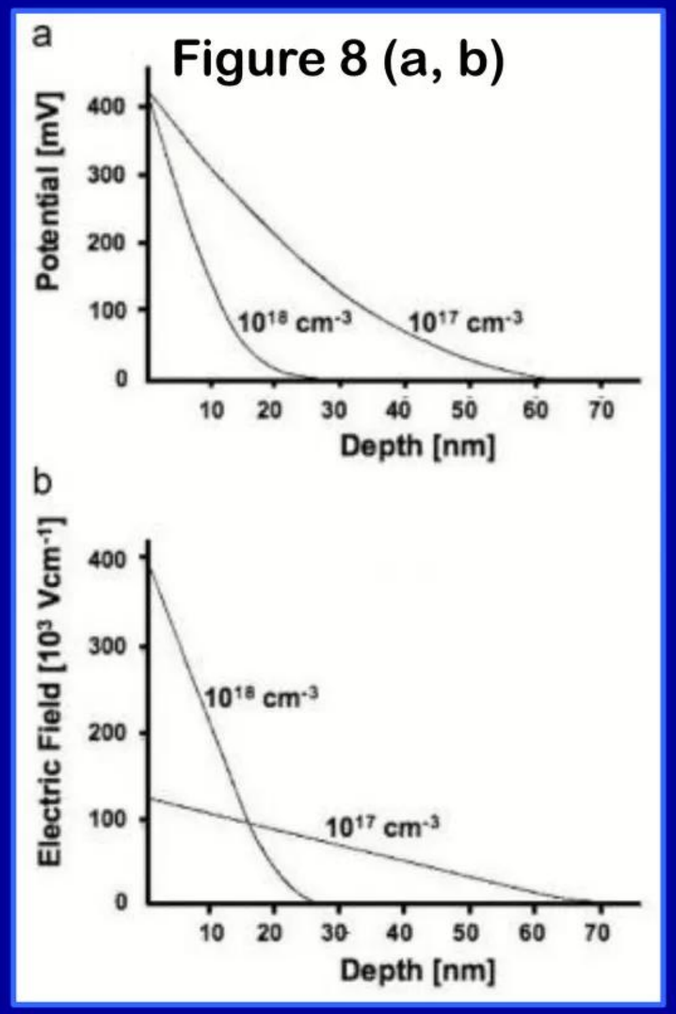
Dissipation of *p*-holes creates high local electric fields

Note that nanoparticles @ surfaces or interfaces amplify electric fields

Air's dielectric breakdown occurs @ electric field strength of ~E_{max}= 3 x 10^6 V/m

"Air ionization at rock surfaces and pre-earthquake signals"
F. Freund *et al.*, *Journal of Atmospheric and Solar-Terrestrial Physics* 71 pp. 1824 (2009)
http://www.princeton.edu/~ipek/Ipek-%20NASA-%20Freund%20etal%202009.pdf

"Stressing one end of a block of igneous rock such as gabbro leads to a series of processes at the unstressed end. First, positive surface potentials appear uniformly across the rock surface, increasing rapidly with increasing stress and reaching about +3 V. Second, massive amounts of positive airborne ions are collected above the unstressed end of the rock. Third, massive amounts of electrons and/or negative airborne ions are collected … around +3 V, the electric field reaches high enough values to extract electrons from neutral gas molecules, e.g. to field-ionize them … most likely candidates for field-ionization are O_2 and H_2O, which have relatively low ionization potentials."



Dahlgren *et al.* recently criticized Freund measurements

Did not follow Freund's very detailed published experimental protocols

Their claimed null results are invalid because experiments conducted improperly

"Comparison of the stress-stimulated current of dry and fluid saturated gabbro samples"
R. Dahlgren *et al.*, *Bulletin of the Seismological Society of America* 104 pp. 2662 (2014)
http://www.crossref.org/iPage?doi=10.1785%2F0120140144

- ✓ Dahlgren *et al.* published paper in which they claimed to have conducted lab experiments which produced data that cast doubt on the existence of Freund's *p*-holes
- ✓ Key problem with their experimental work and resulting reported data is that they did not explicitly follow Freund's published, very detailed experimental protocols
- ✓ They blatantly ignored the well-established fact that strain-induced creation of *p*-holes occurs at *extremely low* activation thresholds; simply handling rocks when setting-up an experiment will generate small fluxes of *p*-holes; need 0 baseline to measure properly
- ✓ Began measurements of positive currents only after subjecting rocks to significant amounts of variable compressive strain for variable periods of time; since only finite numbers of *p*-holes can potentially be generated from a given sample of rock at time t_0, by the time they began measurements, large fractions of the total p-holes produced had already propagated and dissipated --- the inadvertent result of their peculiar method for conducting the experiments was to drastically minimize total measured *p*-hole fluxes
- ✓ Dahlgren *et al.*'s claimed null results are thus invalid and do not refute Freund's data

Johnston's 2001 *JGR* paper also consistent with *p*-holes

Dahlgren's coauthor published experimental data that supports Freund

Experimental results explained w. RFD; causation could just as easily be *p*-holes

"Rapid fluid disruption [RFD]: a source for self-potential anomalies on volcanoes"
M. Johnston *et al.*, *Journal of Geophysical Research* 106 pp. 4327 - 4335 (2001)
http://www.researchgate.net/publication/241581353_Rapid_fluid_disruption_A_source_for_self-potential_anomalies_on_volcanoes

- ✓ Quoting directly from the abstract, "Self-potential (SP) anomalies observed above suspected magma reservoirs, dikes, etc., on various volcanoes (Kilauea, Hawaii; Mount Unzen, Japan; Piton de la Fournaise, Reunion Island, Miyake Jima, Japan) result from transient surface electric fields of tens of millivolts per kilometer and generally have a positive polarity. These SP anomalies are usually attributed to electrokinetic effects where properties controlling this process are poorly constrained. We propose an alternate explanation that contributions to electric fields of correct polarity should be expected from charge generation by fluid vaporization/disruption [RFD]." Note: similar + anomalies have been reported since mid-1970s
- ✓ RFD mechanism proposed by Johnston *et al.* is physically plausible explanation and consistent with data reported in their laboratory experiments with granite. That said, in a careful reading of the paper it appears to me that Freund *p*-holes would be an equally plausible explanation; those interested are urged to read the paper and decide for themselves whether they concur
- ✓ In the fresh light of what is known today about Freund *p*-holes, geophysicists may find it very worthwhile and quite illuminating to reexamine extant literature to locate previously published papers such as this one which reported measurements of positive polarity anomalies. It might very well be determined that for some such data, *p*-holes may provide a much better and more satisfactory explanation for such observations versus previously proposed causative factors

Anomalous IR emissions from land surfaces observed

Emissions appear to be a potential precursor for earthquake activity

Fast changes in IR emissions are inconsistent with heat flow from crustal depths

"Stimulated infrared emission from rocks: assessing a stress indicator"
F. Freund *et al.*, *eEarth* 2 pp. 1 - 10 (2007)
http://solar-center.stanford.edu/SID/educators/FF_IR_emission_eEarth_2_1-10_2007.pdf

Quoting: "… non-stationary, transient areas of enhanced IR emission from the land surface, which have been recognized since the late 1980s and early 1990s in night-time satellite images and linked to impending earthquake activity … reported increase in surface temperatures reach 2 - 4° C, occasionally higher. Such areas of enhanced IR emission are referred to as 'thermal anomalies' … phenomenon of thermal anomalies has remained enigmatic. In many cases the reported increase in temperature seems to correlate poorly with meteorological ground data … rapidity with which the thermal anomalies appear and disappear rules out that they are caused by a flow of Joule heat from a source deep below that would heat the rocks. Several other processes have been invoked to account for the reported temperature increase: (i) rising fluids that could lead to the emanation of warm gases (ii) rising well water levels and changing moisture contents in the soil; (iii) diffuse CO_2 emanation, causing a 'local greenhouse' effect; (iv) Near-ground air ionization due to enhanced radon emission leading to the condensation of water vapor from the atmosphere and, hence, to the release of latent heat. However, at closer inspection, none of these explanations seem to be able to adequately account for characteristic features of the 'thermal anomalies'."

Freund *et al.* measured IR emission from stressed rocks

While it might simply be *p*-hole dissipation it could also signify LENRs

Excited O-O bonds → narrow-band IR emission; LENRs emit broader IR spectra

"Stimulated infrared emission from rocks: assessing a stress indicator"
F. Freund *et al.*, *eEarth* 2 pp. 1 - 10 (2007)
http://solar-center.stanford.edu/SID/educators/FF_IR_emission_eEarth_2_1-10_2007.pdf

- ✓ Freund *et al.*'s proposed *p*-hole recombination mechanism for explaining the experimentally observed IR emission data with mechanically stressed Anorthosite is physically plausible and consistent with their reported results
- ✓ Please note that heavy electrons present during LENRs on surfaces quickly convert energetic gamma radiation directly into infrared; it would appear likely that excess infrared emitted by LENR processes would likely have a somewhat broader energy spectrum; LENRs may or may not have occurred in their experiments (inconclusive) --- however, out in Nature it may be quite different
- ✓ If 'swarms' of arriving *p*-holes triggered LENRs somewhere in topmost meter or two of rocks or soils, would expect to see very rapid increases in IR emissions coming from Earth's surface: this has been repeatedly observed and published

If LENRs were occurring in topmost meter would also expect to observe local increases in fluxes of thermal neutrons well-above normal background levels

Thermal neutron fluxes observed in rock compression

Published Italian experiments demonstrate such neutron production

Reported neutrons from granite but not marble: consistent with Freund *p*-holes

"Piezonuclear neutrons from brittle fracture: early results of mechanical compression tests"
A. Carpinteri *et al. Strain* 45 pp. 332 - 339 (2009)
http://onlinelibrary.wiley.com/doi/10.1111/j.1475-1305.2008.00615.x/abstract
http://staff.polito.it/alberto.carpinteri/papers/CARPINTERI_2009_N.530_STRAIN.pdf

Quoting abstract: "Neutron emission measurements by means of Helium-3 neutron detectors were performed on solid test specimens during crushing failure. The materials used were marble and granite, selected in that they present a different behaviour in compression failure (i.e. a different brittleness index) and a different iron content. All the test specimens were of the same size and shape. Neutron emissions from the granite test specimens were found to be of about one order of magnitude larger than the natural background level at the time of failure. These neutron emissions were caused by piezonuclear reactions that occurred in the granite, but did not occur in the marble. This is because of the fact that in granite the release rate of accumulated elastic energy ΔE exceeds the power threshold for the generation of piezonuclear reactions, $W_{strong} = 7.69 \times 10^{11}$ W. Moreover, granite contains iron, which has been ascertained to be the most favourable element for the production of piezonuclear reactions when the nuclear interaction energy threshold, $E_{0,strong} = 5.888 \times 10^{-8}$ J, is exceeded in deformed space-time conditions."

Thermal neutron fluxes observed in rock compression

Not convinced Carpinteri *et al.*'s neutrons are produced by "fission"

Lattice posits $e + p$ is driven by *p*-hole surface E-fields interacting with Hydrogen

- ✓ As in 2009, in more recent paper (*Sadhana* 37 pp. 59 - 78 2012) Carpinteri *et al.* reiterated claim that they have been observing and measuring production of fluxes of thermal energy (≤0.025 MeV) - not fast - neutrons emitted during their many rock compression experiments
- ✓ Carpinteri *et al.* have attempted to explain such thermal neutrons by postulating (without rigorous theoretical justification) that a "piezonuclear fission" process takes place which emits slow neutrons as non-Actinide elements like Iron (Fe) spontaneously fission into many fragments comprising lighter stable elements; are clearly unaware of Freund's *p*-hole work
- ✓ On basis of their reported experimental results we believe that their "fission" explanation is scientifically untenable, in spite of the fact that Swain *et al.* (http://arxiv.org/abs/1306.5165) have proposed a so-called "electrostrong" collective theoretical framework with believable physics that could potentially enable such an exotic process to operate at significant rates with middleweight elements in condensed matter systems; as to whether it truly does ???
- ✓ Carpinteri *et al.* also claim to have observed "fission products" based on post-experiment EDX analyses supposedly showing huge changes in elements on rock surfaces; like others, we believe their EDX measurements are dubious – claim caused furor amongst researchers
- ✓ We do believe Carpinteri *et al.* have, as claimed, measured fluxes of thermal neutrons; but given that no energetic MeV-energy gammas or neutrons were ever reported, we must conclude that they were not produced via fission but rather by $e + p$ with entangled protons

Other researchers have observed *p*-holes and neutrons

These fascinating reports involve third-party measurements in Nature

Their data is consistent with Freund *p*-holes and Widom-Larsen theory of LENRs

"A large self-potential anomaly and its changes on the quiet Mt. Fuji, Japan"
K. Aizawa, *Geophysical Research Letters* 31 pp. L05612 - 05615 (2004)
http://onlinelibrary.wiley.com/doi/10.1029/2004GL019462/full

- ✓ So-called "self-potential anomaly" at summit could represent the continuous arrival of 'swarms' of positively charged *p*-holes associated with emergence of new fumaroles --- this is consistent with Freund's theoretical expectations

"Observation of the prior earthquake effect on the flux of environmental neutrons, gamma-radiation, and on the local electric field in Tien-Shan mountain"
N. Salikhov *et al.* Cornell preprint *arXiv* (2013)
http://arxiv.org/abs/1301.6965

- ✓ Earthquake activity at Tien-Shan mountain associated with same type of "positive polarity anomaly" as seen by Aizawa at Mt. Fuji summit; dip in measured gamma radiation just prior to quake (formation of heavy electrons converts MeV gammas directly to infrared) and increases in low energy neutron fluxes afterwards are consistent with the Widom-Larsen theory of LENRs and would thus be expected

Take-away: *p*-holes cause positive polarity anomalies; provide input energy for LENRs

Salikhov *et al.*'s arXiv preprint is a brilliant must-read

Correlated changes between gamma/neutron fluxes and electric field

Relationships between all these measurements explained by *p*-holes and LENRs

"Observation of the prior earthquake effect on the flux of environmental neutrons, gamma-radiation, and on the local electric field in Tien-Shan mountain"

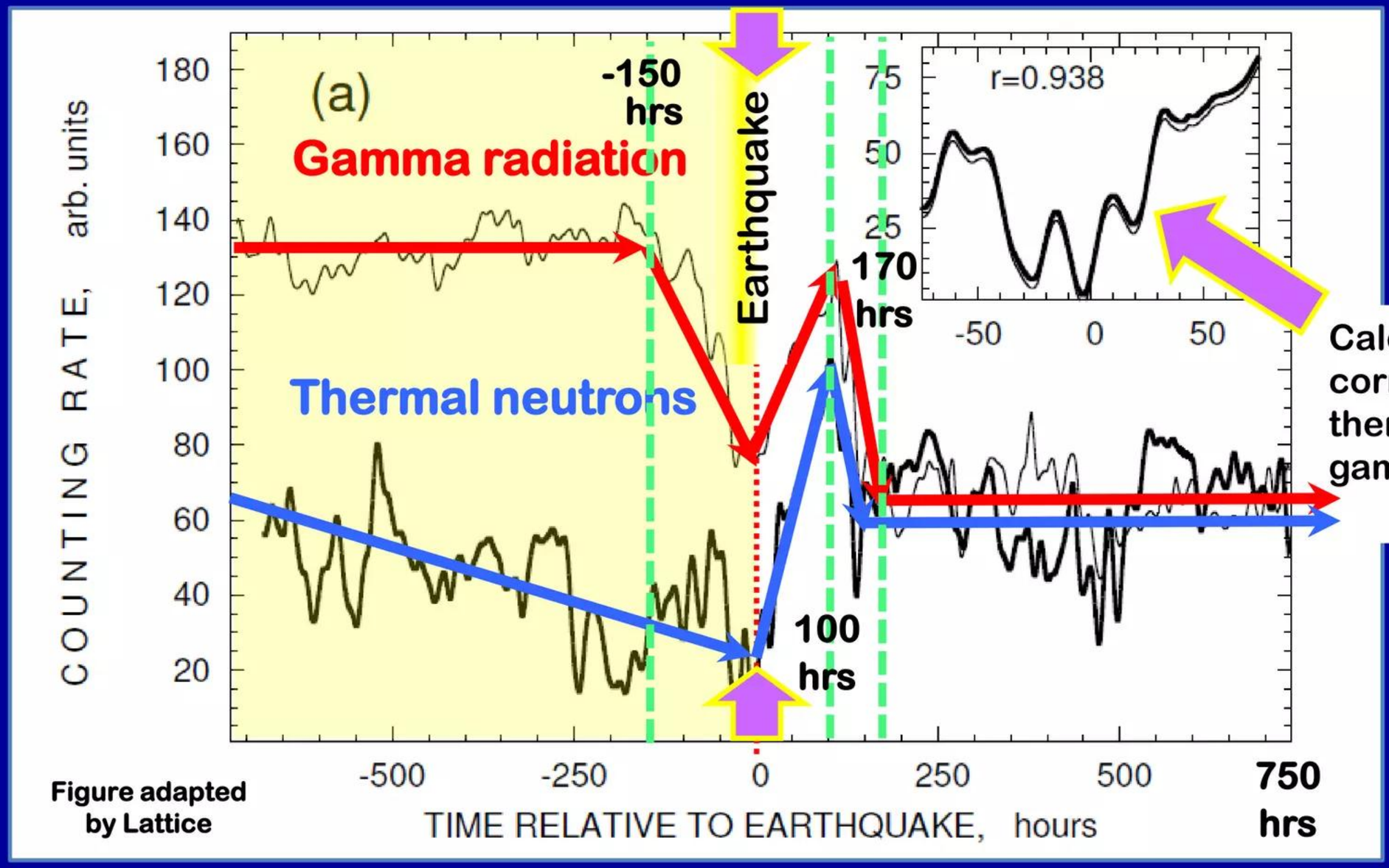
Excerpting from abstract: **"On the eve of, and after a 5.4 magnitude earthquake the fine features in temporal behavior of the intensity of low-energy neutron and gamma-radiation background, so as irregularities of the local electric field were observed which seem to be in a close correlation with each other. These results may be an evidence of the possibility of experimental identification of earthquake's precursors in the time up to 2 - 3 days before the beginning of a period of intensive tectonic activity."**

Quoting further: **"…one can see that the period of anomalous behavior of electric field begins simultaneously with the formerly discussed decrease in the gamma- and thermal neutron signal, and the most intensive electric activity falls on the moment of the deepest dip in the intensity of gamma-radiation and neutron flux, immediately before the main earthquake shock. The latter circumstance is another evidence against any random coincidence, and, contrarily, of a close correlation between these rarely met anomalies in behavior of the three heterogeneous geophysical characteristics … Some characteristic influence of a 5.4 magnitude earthquake has been revealed in monitoring records of the intensity of environmental gamma-radiation, of the flux of low-energy neutrons, and of the local electric field at the complex detector installation of the Tien Shan mountain station. Anomalous variations of these quite different geophysical parameters are in a good correlation with each other both during the 2–3 days long period preceding the earthquake moment, and immediately before and in the time of seismic activity."**

Local occurrence of LENRs readily explains this data

Not explainable as a result of local variability in nuclear decay rates

Data inexplicable as result of huge variations in cosmogenic neutrons/gammas



"Figure 2: Upper panel: time history of the counting rate of thermal neutrons around the 1 May 2011 earthquake moment (bold line) shown in comparison with the gamma-radiation intensity (thin line)"

Salikhov *et al.*'s data consistent with *p*-holes and LENRs

Formation of W-L heavy electrons and $e + p$ reactions explain the data

High correlation between neutrons and gammas because of causal connection

"Observation of the prior earthquake effect on the flux of environmental neutrons, gamma-radiation, and on the local electric field in Tien-Shan mountain"

- ✓ **Data is net result of multiple complex, superimposed processes evolving over time**
- ✓ **Rapid decline in measured gamma radiation from T = -150 hrs to earthquake at Time = 0 consistent with heavy electrons forming and converting any ambient gammas from ~0.5 to 1.0 MeV up through ~10 to 11 MeV directly into broadband infrared (IR)**
- ✓ **Rapid increase in measured low-energy neutrons from Time = 0 up to T = 100 hrs is consistent with local production (relative to locations of neutron detectors) of such neutrons via heavy electron $e + p$ weak reactions powered by input energy from the dissipation of arriving 'swarms' of *p*-holes emanating from distant stressed rocks**
- ✓ **From Time = ~170 hrs out through T = 750 hrs note that both neutron and gamma fluxes level out to a more-or-less steady-state condition in which: (a) measured gamma fluxes *remain* significantly lower than their values prior to earthquake event at T = 0; and (2) fluxes of neutrons generally remain higher than prior to T = 0; this ~steady-state interval from T = 170 - 750 hrs was likely time of continued aftershocks**
- ✓ **Correlation between gamma/neutron data during the sample period relatively high (r = 0.938) because they are truly causally connected as we have explained above**

1990s Italian experiments clarify data of Salikhov *et al.*

Large changes in gammas resulted from presence of heavy electrons

Widom-Larsen explains how heavy electrons convert gammas into IR photons

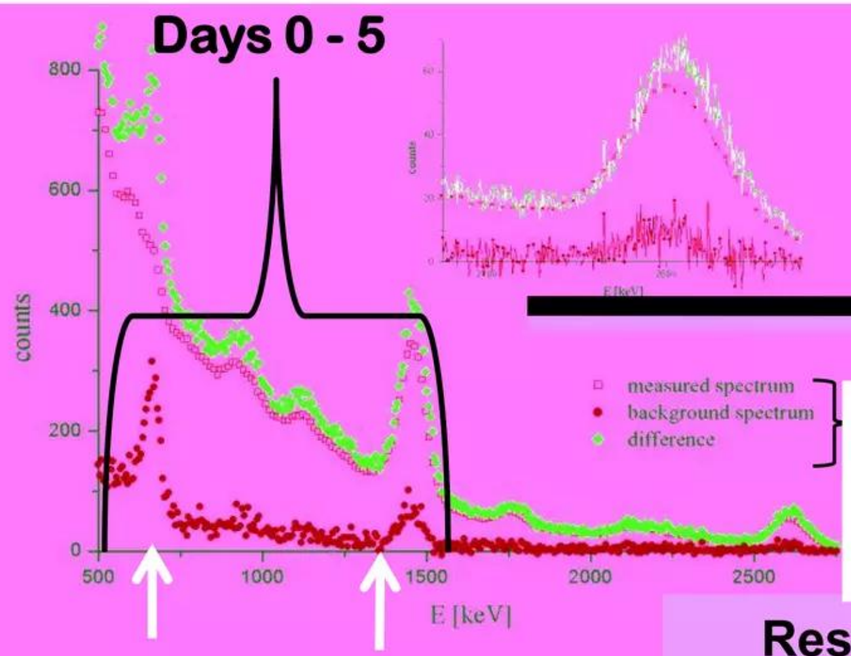
"Nickel-seed LENR networks" see Slides #38 - 44 for a detailed discussion of these experiments
Lewis Larsen, Lattice Energy LLC, April 20, 2011 [61 MS-PowerPoint slides]
http://www.slideshare.net/lewisglarsen/lattice-energy-llcnickelseed-lenr-networksapril-20-2011

- ✓ Major changes in levels of measured gamma radiation during 1990s Italian experiments (see next slide) were caused by same LENR processes that were responsible for variations in gamma and neutron emissions observed before and after Tien-Shan Mountain earthquake as reported by Salikhov *et al.* (2013)
- ✓ Experimental data presented in next slide was originally published by Italian scientists in *Il Nuovo Cimento* which at that time was a peer-reviewed official journal of the Italian Physical Society; after formation of the European Union, it was absorbed into *European Physical Journal* family of academic publications
- ✓ In these Italian experiments LENR neutron fluxes were not measured directly; instead, heat production inside stainless steel reaction cells was measured calorimetrically. Substantial amounts of excess heat observed in some of their experiments probably resulted from captures of ultralow energy neutrons on Nickel in which prompt capture gammas were converted directly into infrared radiation (heat) by heavy-mass electrons present on the same device surfaces
- ✓ Gamma emissions continued to remain lower from Days 6 - 50, just like Tien-Shen

Conference paper by Focardi *et al.* at ICCF-11 (2004)

Fig. 3 (left) and Fig.4 (above right) were copied from pp. 3 of Focardi et al. (ICCF-11 in 2004) and annotated by Lattice as seen below

Lower dark red points: net measured gamma radiation spectrum (difference)



Time - axis

Note: the legend is mislabeled on Figure 3 to left; "difference" is dark red, NOT the bright green dots

Large amounts of excess heat were produced during time period in which gamma emissions were strongly attenuated to background levels only (see timeline for days 6 – 50 below)

Such spectral results consistent with neutron captures on Nickel and gamma conversion via heavy-mass electrons per W-L theory

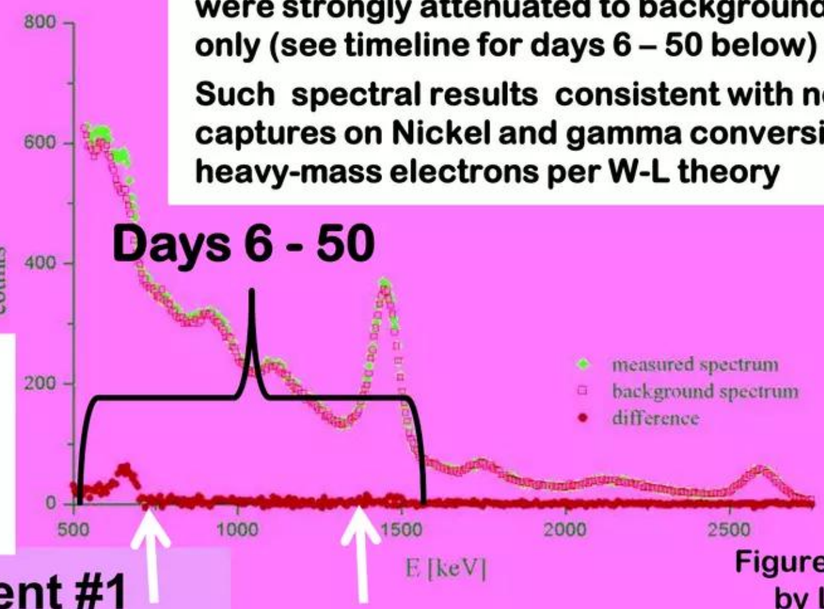


Figure adapted by Lattice

Results of Experiment #1

Quoting: "Figure 3. First experiment: background and measured spectra, at the beginning of gamma measurements, obtained with the NaI(Tl) detector placed in front. The background spectrum is a mean of 90 acquisition (live time 12000 s) while the measured one is a mean of 6 acquisitions. The lower curve is the difference between measured and background spectrum."

Quoting: "Figure 4. First experiment: background and measured spectra 45 days after the beginning of gamma measurements, the measured spectrum is a mean of 18 acquisitions. The lower curve is the difference between measured and background spectra."

Timeline and commentary on key events that occurred during different time periods in Focardi *et al.* Experiment #1

Days into expt.	Focardi *et al.* remark in their paper	Key event	Lattice comments about key events
Day 0 to Day 5	5 days into degassing phase, net measured photon spectrum changed from spectrum of Fig. 3 to what is shown in Fig. 4	Abrupt decrease in gamma spectrum	Heavy SP electrons begin appearing; fields not yet high enough to make large fluxes of ULM neutrons
Day 6 thru Day 50	Day 19 inject H_2 gas - no change in the gamma spectrum; on Day 50 "difference" goes to zero; then only observe normal background radiation levels	Gamma spectrum changes to background only	Bigger population of heavy SP electrons at larger masses; hit threshold for producing ULM neutrons
Day 51 thru Day 85	Quoting: "Later on the cell produced excess power (maximum 25 W …) for about 35 days …"	Total of 25 MJ of heat produced over ~35 days	Neutron captures on seed elements, then various decays; gammas converted to IR by heavy-mass SP electrons

Antonova & Zhumabayev report more Tien-Shan results

Observed: positive polarity + anomalies correlated with earthquakes

"Anomalies of the electric field can be considered as precursors of earthquakes"

"Response of the activation of seismic processes in temporary and spectral characteristics of electric field on Tien-Shan" Vienna, Austria April 27 thru May 7, 2014
V. Antonova & B. Zhumabayev, *Geophysical Research Abstracts* 16 EGU2014-2610 (2014)
http://adsabs.harvard.edu/abs/2014EGUGA..16.2610A

- ✓ Quoting directly from the abstract, "Eight events for 2 days with a magnitude of more than 4.0 occurred on May 1-2, 2011. The main shock of magnitude 5.4 occurred on May 1st at 02:31 UT, 76 km North East of Almaty. Unusual temporal variations of the electric field with amplitude achieving the values of 6-7 kV/m were recorded as during series of earthquakes, and before them (April 28, 30). The duration of the electric field disturbances were 5-12 hours (5 hours on 28.04.2011 and 12 hours on 30.04.2011). Another characteristic of the anomalous variations of the electric field was their positive polarity. The analysis of meteorological and cosmophysical conditions was carried out for the purpose of identification of disturbance sources. It is shown that characteristics of temporal anomalous variations of the electric field don't correspond to these sources of disturbances. It was concluded that the cause of anomalous variations can be sources of the lithospheric origin only. Respectively, anomalies of the electric field can be considered as precursors of earthquakes."

- ✓ If one accepts the proposition that these positive polarity anomalies are in fact caused by Freund *p*-holes, then one can conclude that they may also be precursor signs for earthquakes

Take-away: *p*-holes are likely earthquake precursors if they create + polarity anomalies

What process(es) produce(s) these 'background' neutrons?

Ambient neutron fluxes at ground level on Earth vary with lunar cycles

"Anomalous behavior of thermal neutrons…correlates with…seismic activity"

"Correlation of variations in the thermal neutron flux from the Earth's crust with the Moon's phases and with seismic activity"
V. Alekseenko *et al.*, *Izvestiya, Physics of the Solid Earth* 45 pp. 709 - 718 (2009)
http://adsabs.harvard.edu/abs/2009IzPSE..45..709A

- ✓ Abstract: "The results of the long-term recording of thermal neutron flux near the Earth's surface with the use of an unshielded scintillation thermal-neutron detector are presented. **The data obtained indicate the presence of periodic variations in the thermal neutron flux with the lunar diurnal and the lunar monthly periods.** A hypothesis about the existence in the Earth's crust of radon-neutron tidal variations in the concentration of thermal neutrons, correlated with the Moon's phases and which have the gravitational origin, is formulated and confirmed experimentally. A simple mathematical model is proposed, which satisfactorily describes the observed variations. **The case of the anomalous behavior of thermal neutrons is presented, which correlates with the high local seismic activity.**"

- ✓ Similar to oceans, strain forces in rocks comprising Earth's upper crust will go up and down in synchrony with variation of tidal gravitational pull from the Moon as it circles Earth in its orbit. More *p*-holes will be generated and propagate through the crust as tidal forces increase strain put on crustal rocks. **If dissipation of *p*-holes provided input energy for LENR processes, would expect some components of total thermal neutron flux to mirror lunar cycles, as was observed**

Take-away: neutrons produced by LENRs in Earth's crust can also vary with lunar cycles

Russians claim neutrons can be earthquake precursors

Neutron production is "related to nuclear reactions in Earth's interior"

"Verified … neutron generation occur during early stages of strong earthquakes"

"Relationship between solar activity and global seismicity and neutrons of terrestrial origin"
I. Shestopalov and E. Kharin, *Russian Journal of Earth Sciences* 14 pp. ES1002 - 12 (2014)
http://elpub.wdcb.ru/journals/rjes/doi/2014ES000536.html

Excerpt from the abstract: "The correlation between solar activity and global seismicity in 1680 - 2012 was studied. The authors discovered the global cycles of seismicity of the Earth, related to solar activity. They observed the solar cycles with a small number of spots, typical for the beginning of secular cycles, and strong seismic activity, which remained high throughout several decades. The scientists established a significant negative correlation between seismicity and solar activity. They revealed an absolute maximum of global seismic activity in the 20th century and discovered spatial-temporal regularities of manifestations of global seismicity. Experiments, which were simultaneously carried out at the Pushkov Institute of geomagnetism, Ionosphere and Radiowave Propagation (IZMIRAN), Russian Academy of Sciences, Moscow and the Kamchatka Branch of Geophysical Survey, Russian Academy of Sciences, have verified the suggestion that neutron generation occur during the early stages of strong earthquakes. It was supposed that the mechanism of primary generation of terrestrial neutrons is related to nuclear reactions in the Earth's interior."

Take-away: neutrons may be earthquake precursors; seismic correlation --- see next slide

Inverse relationship of solar activity vs. Earth's seismicity

Assuming relationship is real what mechanism could possibly explain it

Neutrino fluxes from Sun's $e + p$ reactions could reduce $e + p$ rates in Earth's crust

"Relationship between solar activity and global seismicity and neutrons of terrestrial origin"
I. Shestopalov and E. Kharin (2014)

- ✓ For discussion purposes assume: (1) claimed inverse relationship is real ; (2) $e + p$ neutron catalyzed LENRs in Earth's crust locally weaken rocks and thus will help facilitate seismicity
- ✓ Further note that neutrinos, unlike 'normal' E-M photons, are fermions, NOT bosons; this means that $e + p$ reactions producing neutrons and neutrinos obey Pauli Exclusion Principle
- ✓ Per Widom-Larsen theory, $e + p$ reactions and LENRs are occurring outside the Sun's core, especially in active sunspot flares and coronal mass ejections that occur at their highest frequency during peaks in solar activity; fluxes of solar $e + p$ neutrinos would likely dwarf $e + p$ rates occurring on Earth; Pauli Exclusion Principle would slow earthly $e + p$ reactions
- ✓ If all of above assumptions held true in Nature, peaks in $e + p$ rates on the Sun would have the physical effect of reducing $e + p$ neutron production occurring in earth's crust which would in turn cause a drop in terrestrial seismicity, which is what they say their data shows
- ✓ Alteration of $e + p$ and β decay rates in Earth's environs explained in 3 Lattice documents:

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-changes-in-solar-neutrino-fluxes-alter-nuclear-betadecay-rates-on-earthjune-3-2011

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-collective-manybody-qm-neutrino-antennasjan-10-2012

http://www.slideshare.net/lewisglarsen/lattice-energy-llcobserved-variations-in-rates-of-nuclear-decaynov-23-2012

Reports of major isotopic anomalies are accumulating

For years researchers assumed $^{238}U/^{235}U$ ratio was invariant - it is not

What causes unexpected variance: just chemical fractionation or LENRs also?

"$^{238}U/^{235}U$ systematics in terrestrial Uranium-bearing minerals"
J. Hiess *et al.* , *Science* 335 no. 6076 pp. 1610-1614 (2012)
http://www.sciencemag.org/content/335/6076/1610.full

Highest variability in the $^{238}U/^{235}U$ ratio occurs in terrestrial materials originating in low-temperature chemical precipitates, redox ores, and/or sedimentary environments. This category accurately describes the natural environment found in the Rifle, Colorado, study site in which soil bacteria are clearly involved in shifting the $^{238}U/^{235}U$ ratio as well as triggering significant, time-varying shifts in Sulfur isotope abundances during roughly contemporaneous, spatially nearby redox reactions. Fig. 3 again strongly suggests that terrestrial bacteria are the culprits behind observed isotopic shifts in Uranium and Sulfur in soils and rocks. Crucial question: are these observed shifts produced by 'ordinary' chemical fractionation or LENR processes or both? This issue begs for further investigation.

Reports of major isotopic anomalies are accumulating

Bopp *et al.* show that soil bacteria are altering $^{238}U/^{235}U$ isotopic ratios

Question as to whether cause is chemical fractionation or LENRs still unresolved

"Uranium $^{238}U/^{235}U$ isotope ratios as indicators of reduction: results from an *in situ* biostimulation experiment at Rifle, Colorado, U.S.A."
C. Bopp *et al.*. *Environmental Science & Technology* 44 pp. 5927 - 5933 (2010)
http://pubs.acs.org/doi/abs/10.1021/es100643v

- ✓ Although not explicitly acknowledged by chemical isotopic fractionation theorists, an intrinsic fundamental assumption underlying all such theory and interpretation of data is that no nucleosynthetic processes are occurring anywhere in any of these systems, at any time, that are capable of altering isotope ratios and/or producing new mixtures of different elements over time; ergo, they are assuming that chemistry alone explains everything
- ✓ If Widom-Larsen theory LENRs occur out in Nature, albeit at extremely low rates, above-noted fundamental assumption is evidently wrong for a subset of such anomalous data
- ✓ If hypothesized chemical fractionation mechanisms truly worked as well on Uranium isotopes in non-gas-phase systems as proponents have claimed, one would presume that such effects would have been utilized long ago in at least one government nuclear weapons or commercial Uranium enrichment program somewhere in the world, e.g. Iran today. To our knowledge, during the past 70 years they have never been used for such a purpose anywhere. This suggests that, while they may be logical, so-called "nuclear field shift effects" are inadequate explanations for observed changes in Uranium isotope ratios

Many new exciting discoveries about bacterial energetics

"Extracellular reduction of Uranium via *Geobacter* conductive pili as a protective cellular mechanism"
D. Cologgi *et al.*, *Proceedings of the National Academy of Sciences* (PNAS) 108 pp. 15248 - 15242 (2011)
http://www.pnas.org/content/108/37/15248.full.pdf+htm

- ✓ Many papers involving the use of various types of very sensitive mass spectroscopy analysis report anomalous isotopic shifts in elements ranging from Hydrogen to Uranium that are obviously associated with activities of many bacterial species, especially the extremophiles
- ✓ Key question: how much might be caused by LENRs vs. just prosaic chemical fractionation?
- ✓ If some of it is LENRs, where does necessary external input energy to make ultralow energy neutrons come from? Is energetically expensive; requires equivalent of ~10 - 15 million ATP molecules to make one neutron. It is known that electricity is ideal LENR input power source
- ✓ Interestingly and importantly, microbiologists have recently discovered existence of highly conductive nanowires that interconnect many different species of soil and crustal bacteria. More recently, have discovered bacteria that can live on electricity as sole energy source
- ✓ This juxtaposition of exciting new discoveries opens-up the possibility that bacteria may be living in soils and deep in the Earth's crust that could utilize electricity as a source of input energy for driving LENR-based nucleosynthetic processes that can alter isotopic ratios

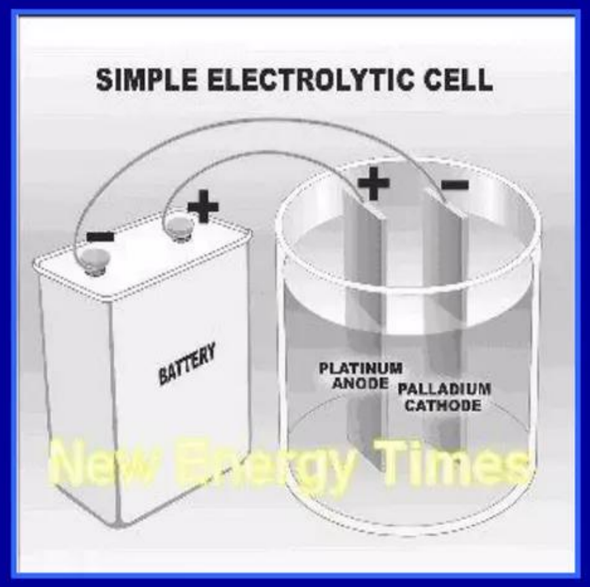
What process might potentially create source of electrical power inside the Earth that could be harvested by bacteria and used for chemical metabolism and LENR nucleosynthesis? We will see how dissipation of electronic energy by Freund *p*-holes could provide input energy

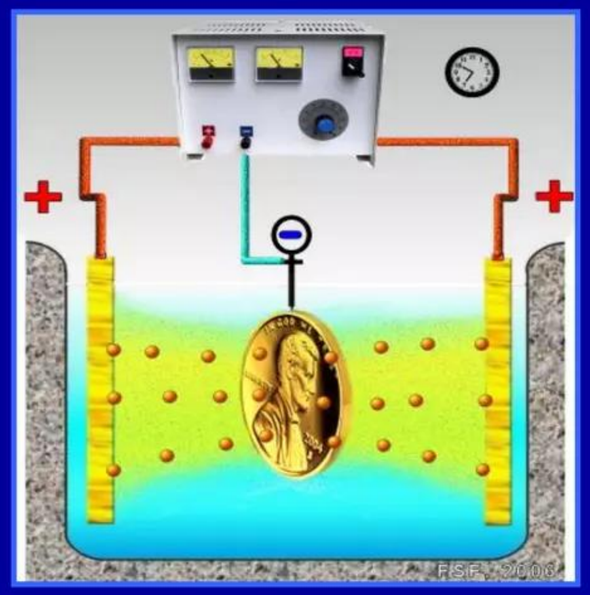
Are bacteria really transmuting elements out in Nature?

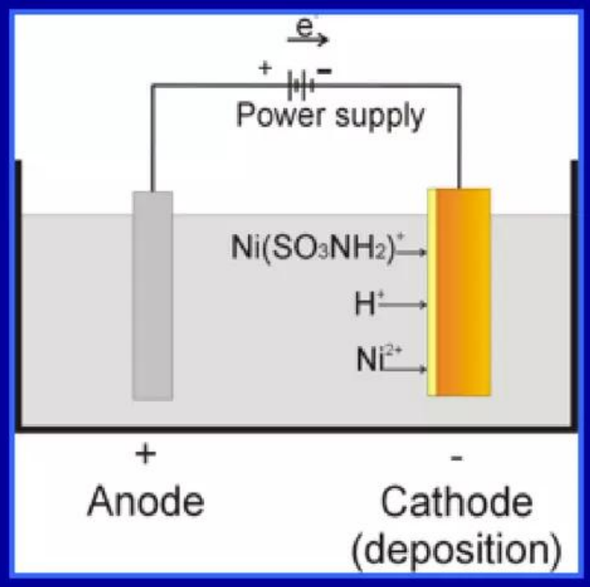
Possibly occurring in: soils, upper crust, undersea hydrothermal vents

Collective electronic interactions amongst bacteria akin to LENR chemical cells

Now, fascinating new facts and speculation about electric bacteria - recent exciting discoveries by microbiologists have revealed that electric potentials, currents, and nanowires are associated with the activities of a number of different species of bacteria; how might this relate to possibility of natural LENRs in hydrothermal vent systems? First, examine the concept of a LENR electrolytic chemical cell:







Above are various conceptual schematics of a type of aqueous light-water electrolytic chemical cells used in many LENR experiments (typically would use DC power supply instead of a battery as a source of electrical current). Please note that using mass spectroscopy for post-experiment analyses, LENR researchers have carefully documented and reported production (via transmutation) of minute amounts of many different elements and isotopically shifted stable isotopes on the surfaces of cathodes found in such cells. In certain cases, the array of transmutation products was quite large

Are bacteria really transmuting elements out in Nature?

Scientists discovering that "electric bacteria" may well be ubiquitous

"Shows that [bacterial] life can handle the energy in its purest form - electrons"

"Meet the electric life forms that live on pure energy"
Catherine Brahic in *New Scientist: Life* July 16, 2014

Source: http://www.newscientist.com/article/dn25894-meet-the-electric-life-forms-that-live-on-pure-energy.html

Quoting excerpts directly: "Unlike any other life on Earth, these extraordinary bacteria use energy in its purest form – they eat and breathe electrons – and they are everywhere."

"Stick an electrode in the ground, pump electrons down it, and they will come: living cells that eat electricity. We have known bacteria to survive on a variety of energy sources, but none as weird as this. Think of Frankenstein's monster, brought to life by galvanic energy, except these 'electric bacteria' are very real and are popping up all over the place."

"Unlike any other living thing on Earth, electric bacteria use energy in its purest form – naked electricity in the shape of electrons harvested from rocks and metals. We already knew about two types, *Shewanella* and *Geobacter*. Now, biologists are showing that they can entice many more out of rocks and marine mud by tempting them with a bit of electrical juice. Experiments growing bacteria on battery electrodes demonstrate that these novel, mind-boggling forms of life are essentially eating and excreting electricity." Excellent, well-written popular article

Are bacteria really transmuting elements out in Nature?

"Such bacteria are showing up everywhere we look, says Lars Nielsen."

"Bacterial cells that both eat and breathe electrons will soon be discovered"

"Meet the electric life forms that live on pure energy"

Catherine Brahic in *New Scientist: Life* July 16, 2014

Source: http://www.newscientist.com/article/dn25894-meet-the-electric-life-forms-that-live-on-pure-energy.html

Quoting excerpts directly: "Electric bacteria come in all shapes and sizes. A few years ago, biologists discovered that some produce hair-like filaments that act as wires, ferrying electrons back and forth between the cells and their wider environment. They dubbed them microbial nanowires."

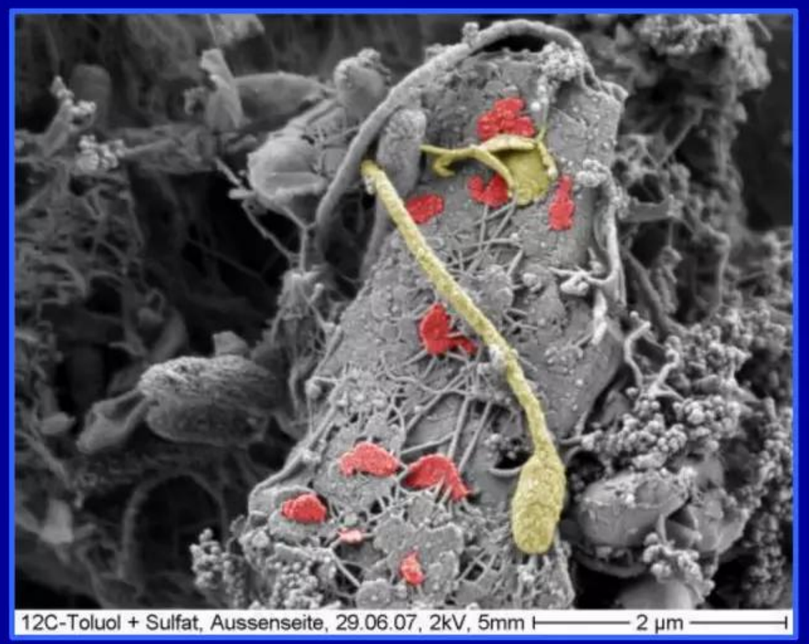
"Lars Peter Nielsen and his colleagues at Aarhus University in Denmark have found that tens of thousands of electric bacteria can join together to form daisy chains that carry electrons over several centimetres – a huge distance for a bacterium only 3 or 4 micrometres long."

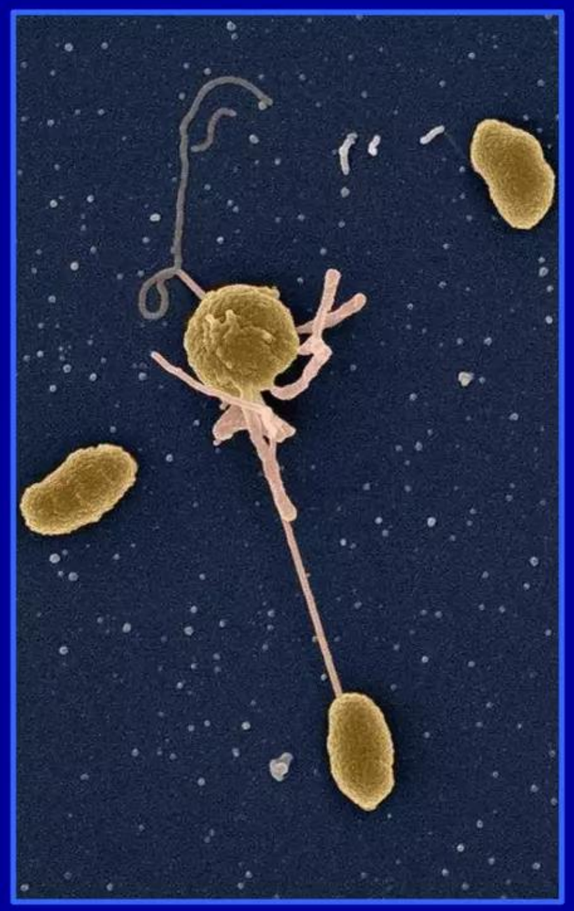
"Such bacteria are showing up everywhere we look, says Nielsen."

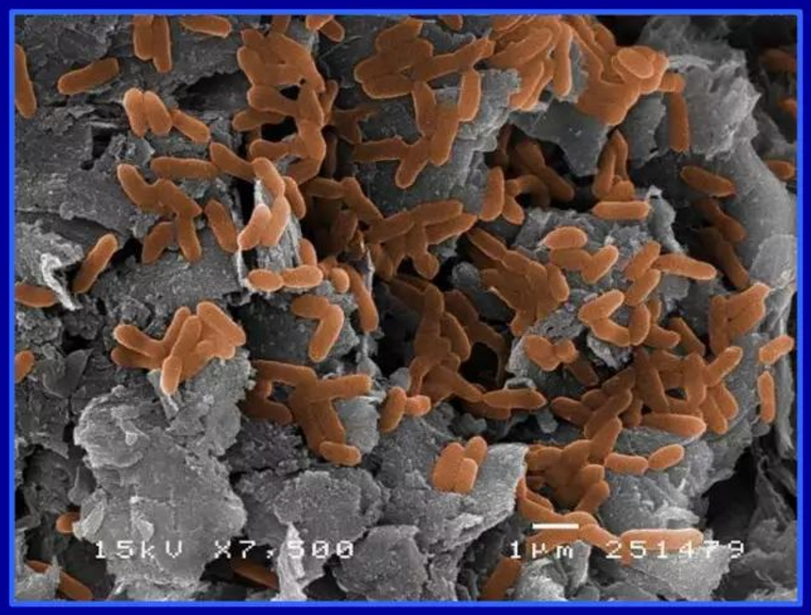
"Early work shows that such cables [bacterial nanowires] conduct electricity about as well as the wires that connect your toaster to the mains."

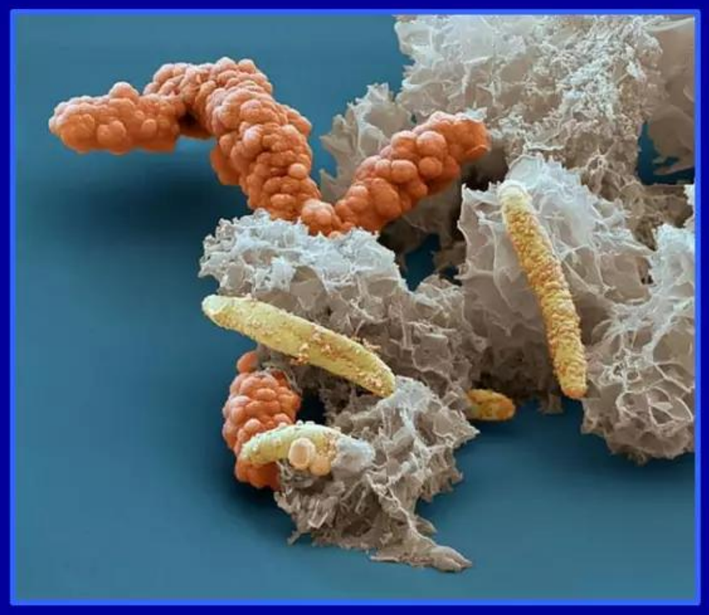
Bacteria often grow in close proximity to mineral surfaces

Although not shown in all SEM images bacteria connected by nanowires

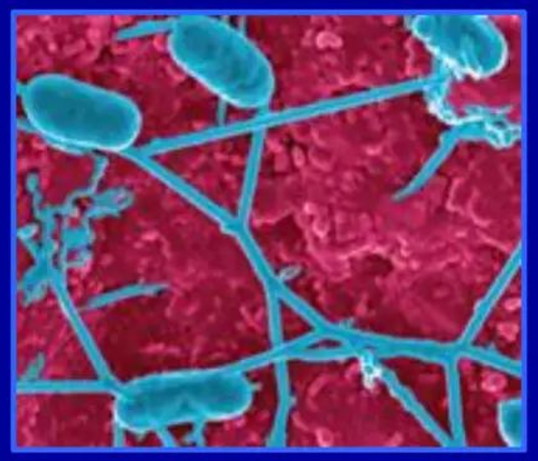






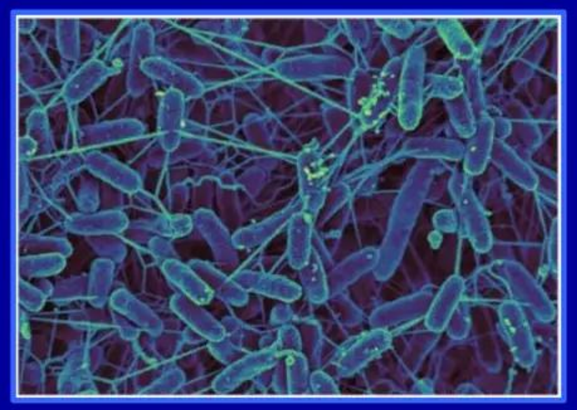


Bacteria often grow in close proximity to mineral surfaces



Geobacter sp. nanowires

Highly conductive bacterial nanowires interconnect bacterial cells



Shewanella oneidensis nanowires

Typical rock surfaces are negatively charged

Rock substrate that is suitable conductor for Freund *p*-holes

Conceptual: not to scale

Bacteria interconnected by current-carrying nanowires

Mobile electrons are present at surface of conductive rock substrate

p-holes absent here; only modest currents now flowing thru bacterial nanowires

Highly conductive bacterial nanowires interconnect bacterial cells

Time = t_0

Only modest electron currents now flowing thru bacterial nanowires

Time = t_0

Only modest electron currents now flowing thru bacterial nanowires

Typical rock surfaces are negatively charged

Rock substrate that is suitable conductor for Freund *p*-holes

Conceptual: not to scale

Hypothesis: *p*-hole approaches rock surface from below

Mobile electrons are present at surface of conductive rock substrate

Conceptual: many-body quasiparticle is now approaching surface (not to scale)

Highly conductive bacterial nanowires interconnect bacterial cells

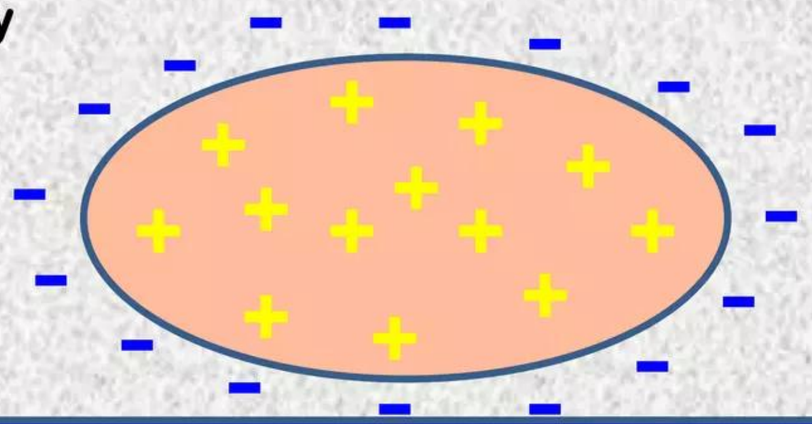
Time = t_0 + 1

Only modest electron currents now flowing thru bacterial nanowires

Time = t_0 + 1

Only modest electron currents now flowing thru bacterial nanowires

Note: detailed microphysics of *p*-holes is not yet worked-out; how much is chemistry vs. how much is it a purely electronic, quantum mechanically entangled, many-body collective quasiparticle with a positive charge???



p-hole direction of motion

Hypothesis: electrons rush-in to neutralize *p*-hole charge

Mobile electrons are present at surface of a conductive rock substrate

Conceptual: a many-body *p*-hole quasiparticle has just now impacted the surface

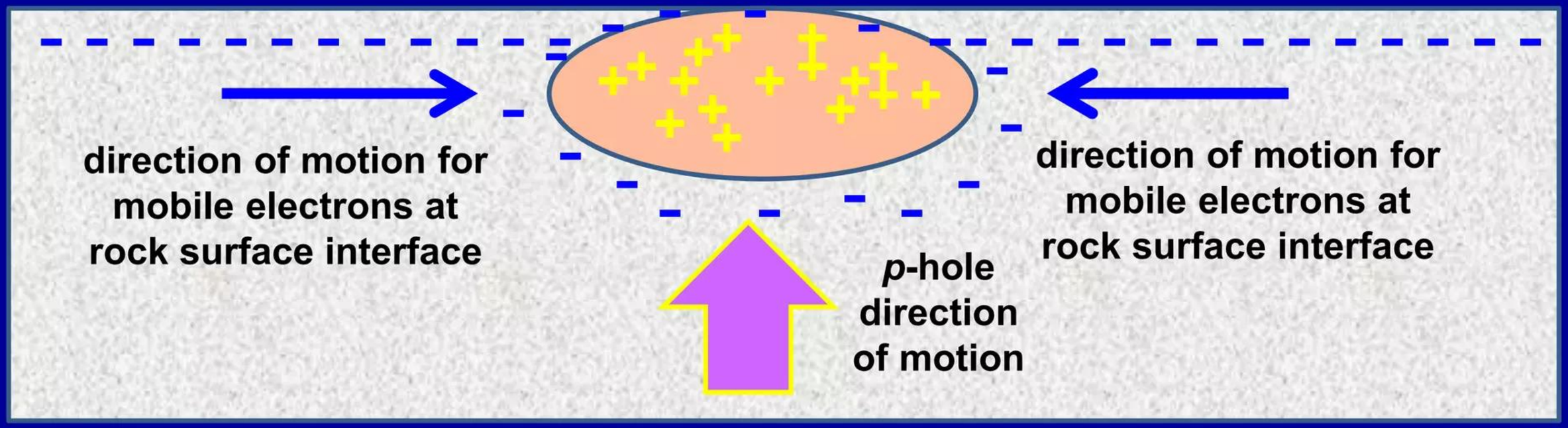
Highly conductive bacterial nanowires interconnect bacterial cells

Time = t_0 + 2

Only modest electron currents now flowing thru bacterial nanowires

Time = t_0 + 2

Only modest electron currents now flowing thru bacterial nanowires



Hypothesis: high local E-field bathes bacterial nanowires

Mobile electrons present at surface of *p*-hole conducting rock substrate

Motion of surface charges creates high fast-changing local electromagnetic field

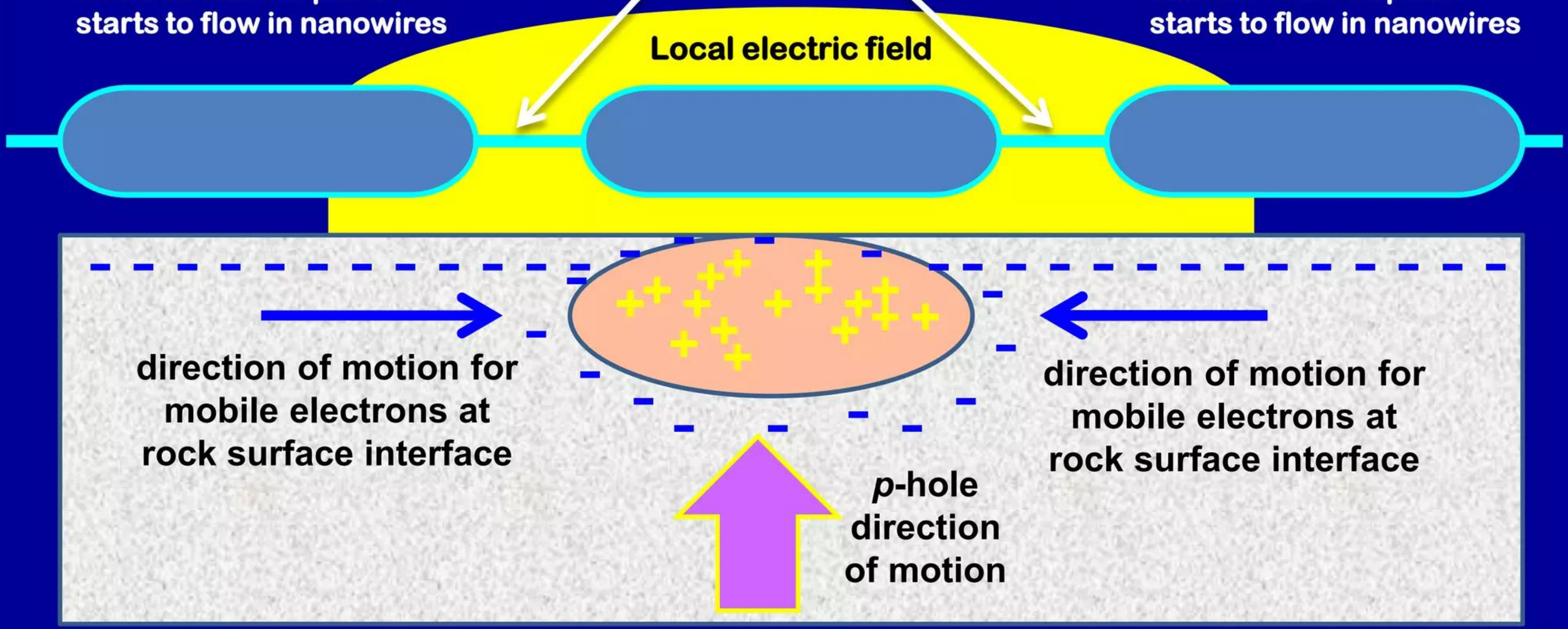
Changing E-M field induces an electric current pulse in conductive bacterial nanowires

Time = t_0 + 3

Much larger induced local electron current pulse starts to flow in nanowires

Time = t_0 + 3

Much larger induced local electron current pulse starts to flow in nanowires

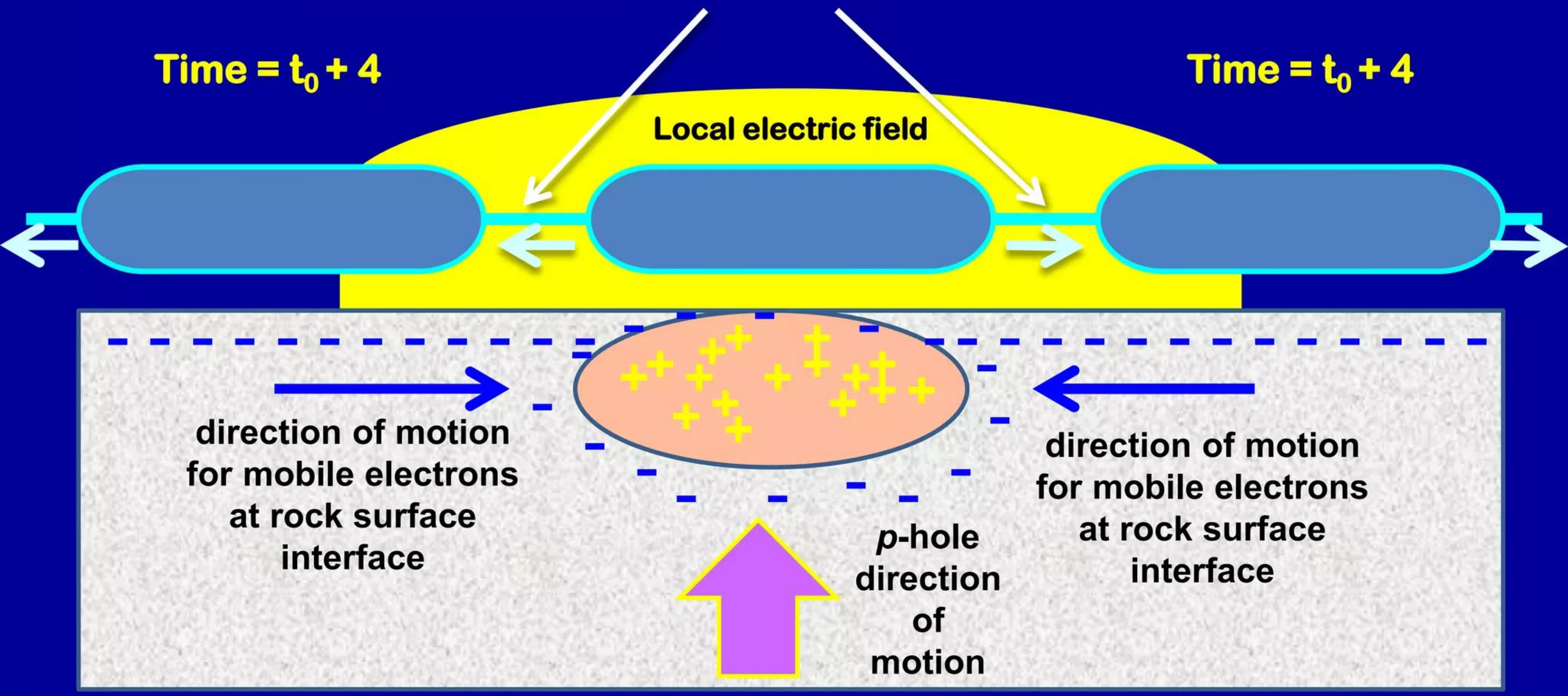


Hypothesis: bacterial networks harvest induced currents

Mobile electrons present at surface of *p*-hole conducting rock substrate

Motion of surface charges creates high fast-changing local electromagnetic field

Electric current pulse dissipated by rapidly distributing its energy via highly conductive nanowires across a collective many-bacteria local electrical network



Hypothesis: bacterial electric network returns to t_0 state

p-hole now gone: the bacterial network has captured electrical energy

Bacteria are undamaged by *p*-holes because do not interact directly with them

p-hole energy has been harvested and mostly dissipated harmlessly as electric currents

Rock substrate that is suitable conductor for Freund *p*-holes

p-holes can provide energy source for electric bacteria

Was ability to use electricity first evolved by bacteria living in crust?

p-holes and LENRs: lifesavers in crust with very low porosity and few nutrients

- ✓ Deeper in the crust, where porosity is quite low and local availability of very slowly replenished chemical nutrients is extremely limited, evolving an ability to utilize purely electronic energy by harvesting *p*-holes would have conferred a very large competitive advantage vs. bacteria totally dependent on chemical energy sources
- ✓ Given all that, did electric bacteria first evolve deeper in Earth's crust rather than elsewhere as result of selective pressures operating down in the Deep Biosphere?
- ✓ Given that (as Freund has shown) Hydrogen is relatively abundant in rocks that are common in upper crust, and given that episodic fluxes of *p*-holes would provide adequate energy to support bacterial LENRs, an ability to synthesize new elements (unavailable in locally accessible rock) via hard radiation-free LENR transmutation processes would provide major competitive advantage to any bacteria able to do it
- ✓ Bacterial transmutations were discovered by a Russian microbiologist working with a Ukrainian physicist in Moscow 13 years ago; however, at that time nobody believed their published experimental results. In 2012, the controversial Russian data was finally confirmed by a team of Indian scientists working at the Indira Gandhi Centre for Atomic Research (IGCAR - located in Kalpakkam, India); as far as we know, they are apparently still trying to get the paper published in a journal

Working with Lattice

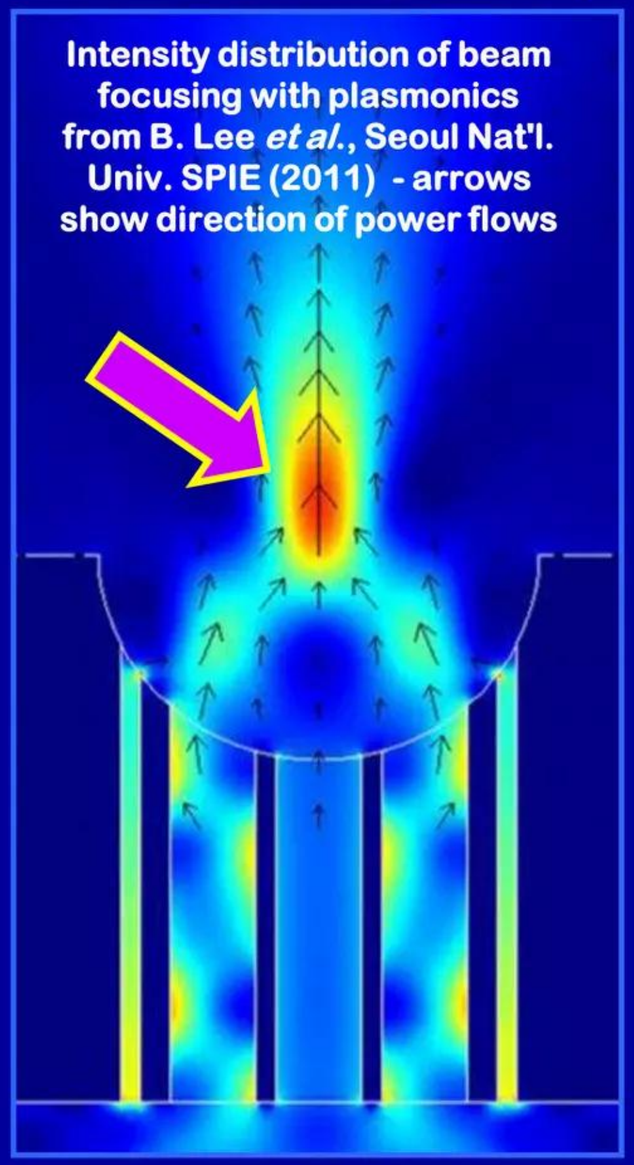
Partnering on commercialization and consulting on certain topics

Larsen cv: http://www.slideshare.net/lewisglarsen/lewis-g-larsen-cv-june-2013

1-312-861-0115 lewisglarsen@gmail.com

- ✓ **Lattice welcomes serious inquiries from large, established organizations that have an interest in discussing the possibility of becoming a strategic capital and/or technology development partner**
- ✓ **Lewis Larsen also selectively engages in fee-based third-party consulting that does not compromise Lattice's proprietary intellectual property relating to LENR power sources. Such expertise includes many areas such as thermal runaways in Li-ion batteries; LENRs as they relate to petroleum geochemistry and fracking-induced seismicity; long-term strategic implications of LENRs on high cap-ex long term investments in power generation and petroleum-related assets; as well as long-term outlooks for real prices of energy, precious metals, and other commodities**

Concentrating E-M energy in resonant electromagnetic cavity



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

Additional reading for further details

Lattice document discusses published experimental evidence that suggests microbial LENRs exist:

"Some bacteria appear capable of altering isotopic ratios of Uranium --- Is it the result of prosaic chemical fractionation processes and/or LENRs?"
Lewis Larsen, Lattice Energy LLC, December 7, 2010 [50-page technical MS-Word document]

http://www.slideshare.net/lewisglarsen/bacteria-lenrsand-isotopic-shifts-in-uraniumlarsenlattice-energy-dec-7-2010-6177275

Index to large collection of online documents re LENR theory, experimental data, and the technology:

"Index to key concepts and documents" v. #19 ******* RECENTLY UPDATED *******
L. Larsen, Lattice Energy LLC, May 28, 2013 [119 slides] Updated and revised through August 19, 2014

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-index-to-documents-re-widomlarsen-theory-of-lenrsmay-28-2013

Review paper that covers all theoretical aspects of basic Widom-Larsen theory published to date:

"A primer for electro-weak induced low energy nuclear reactions"
Y. Srivastava, A. Widom, and L. Larsen, *Pramana - Journal of Physics* 75 pp. 617 - 637 (2010)

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."

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

"Not only is the universe stranger than we imagine, it is stranger than we *can* imagine."

Often misattributed to Sir Arthur Eddington;
more likely adapted from J.B.S. Haldane (1927)

Laura 13

Shewanella oneidensis
Image: R. Bencheikh and B. Arey
Nanowires interconnecting many bacteria
PNAS (DOI: 10.1073/pnas.0604517103)