Commercializing a next-generation source of CLENR energy

Low Energy Nuclear Reactions (LENRs)

New neutron data consistent with WLS mechanism in lightning

Surprisingly large fluxes of low-energy neutrons well-correlated with thunderstorm EMF fluctuations

Technical Overview

Multiple Lightning Bolts

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

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

Nuclear reactions

Lewis Larsen

President and CEO
Lattice Energy LLC
April 4, 2012

"It is of the highest importance in the art of detection to be able to recognize, out of a number of facts, which are incidental and which vital. Otherwise your energy and attention must be dissipated instead of being concentrated."

Sherlock Holmes, "The Reigate Squires" 1893

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

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

Beta⁻ decay of neutron-rich products

Single Lightning Bolt

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

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

Nuclear reactions

WLS theory suggests LENRs could occur in many places

Cores of stars, fission reactors, and supernovae are not required

Lightning is like exploding wires

Earth has lightning in many places

March 19, 2011 – image of major eruption on the surface of the Sun
Nucleosynthesis *also* occurs in photosphere, flux tubes, and corona

Very dusty Eagle Nebula

Jupiter is not just a 'failed star'

Contents

Contents (continued)

Main objectives of presentation

Neutron production and nucleosynthesis can occur in lightning discharges

- ✓ **Discuss selected features of WLS theory that apply mainly to atmospheric lightning processes**
- ✓ **Outline portion of the WLS theory that provides a simple, many-body collective magnetic mechanism which can produce substantial fluxes of neutrons via the weak interaction in lightning discharges (which is very much like an exploding wire); such neutron production occurs in both ionized lightning plasmas and on the surfaces of condensed matter grains trapped in dusty lightning channels**
- ✓ **Review new experimental evidence just reported by a Russian team in *Physical Review Letters* that shows surprisingly large fluxes of low energy neutrons that are temporally well-correlated with atmospheric lightning discharges; their experiments are discussed in some detail**
- ✓ **Provide overview explaining how WLS mechanism in lightning enables measurable amounts of nucleosynthesis to occur in planetary environments; this is somewhat contrary to presently accepted astrophysical paradigms where neutron-driven nucleosynthesis is thought to be strictly limited to stars, supernovae, and other types of large, very hot astrophysical objects**
- ✓ **Review published papers on other researchers' latest thinking about the environment of the dusty presolar nebula; lightning discharges now thought to be a very important process. If their conjecture is correct, then non-stellar nebular LENR nucleosynthesis had to be occurring before planets formed**
- ✓ **Summary: low yet measurable rates of lightning-driven WLS LENR nucleosynthesis have probably been occurring in the environs of the solar system for >4.5 billion years. This more recent LENR transmutation activity has likely been superimposed on top of the reaction products originating from even more ancient stellar fusion and supernova processes. Are telltale isotopic 'signatures' of non-stellar LENR processes present in published isotopic data obtained from NASA's Genesis mission?**

Many-body collective effects are commonplace in Nature

WLS paradigm shift: welcome to the New World of nucleosynthesis

"I am increasingly persuaded that all physical law we know about has collective origins, not just some of it.“

"… I think a good case can be made that science has now moved from an Age of Reductionism to an Age of Emergence, a time when the search for ultimate causes of things shifts from the behavior of parts to the behavior of the collective ….. Over time, careful quantitative study of microscopic parts has revealed that at the primitive level at least, collective principles of organization are not just a quaint sideshow but everything --- the true essence of physical law, including perhaps the most fundamental laws we know … nature is now revealed to be an enormous tower of truths, each descending from its parent, and then transcending that parent, as the scale of measurement increases."

"Like Columbus or Marco Polo, we set out to explore a new country but instead discovered a new world."

Robert Laughlin, "A Different Universe - Reinventing Physics from the Bottom Down," Basic Books, 2005, pp. xv and 208

Many-body collective effects are commonplace in Nature

Certain quantum mechanical effects are key to LENRs in realm of condensed matter

"Another biological process where entanglement may operate is photosynthesis, the process whereby plants convert sunlight into chemical energy. Incident light ejects electrons inside plant cells, and these electrons all need to find their way to the same place: the chemical reaction center where they can deposit their energy and sett off reactions that fuel plant cells. Classical physics fails to explain the near-perfect efficiency with which they do so."

"... In a quantum world, a particle does not just have to take one path at a time; it can take all of them simultaneously. The electromagnetic fields within plant cells can cause some of these paths to cancel one another and others to reinforce mutually, thereby reducing the chance the electron will take a wasteful detour and increasing the chance it will be steered straight to the reaction center."

"The entanglement would last only a fraction of a second and would involve molecules that have no more than about 100,000 atoms. Do any instances of larger and more persistent entanglement exist in nature? We do not know, but the question is exciting enough to stimulate and emerging discipline: quantum biology."

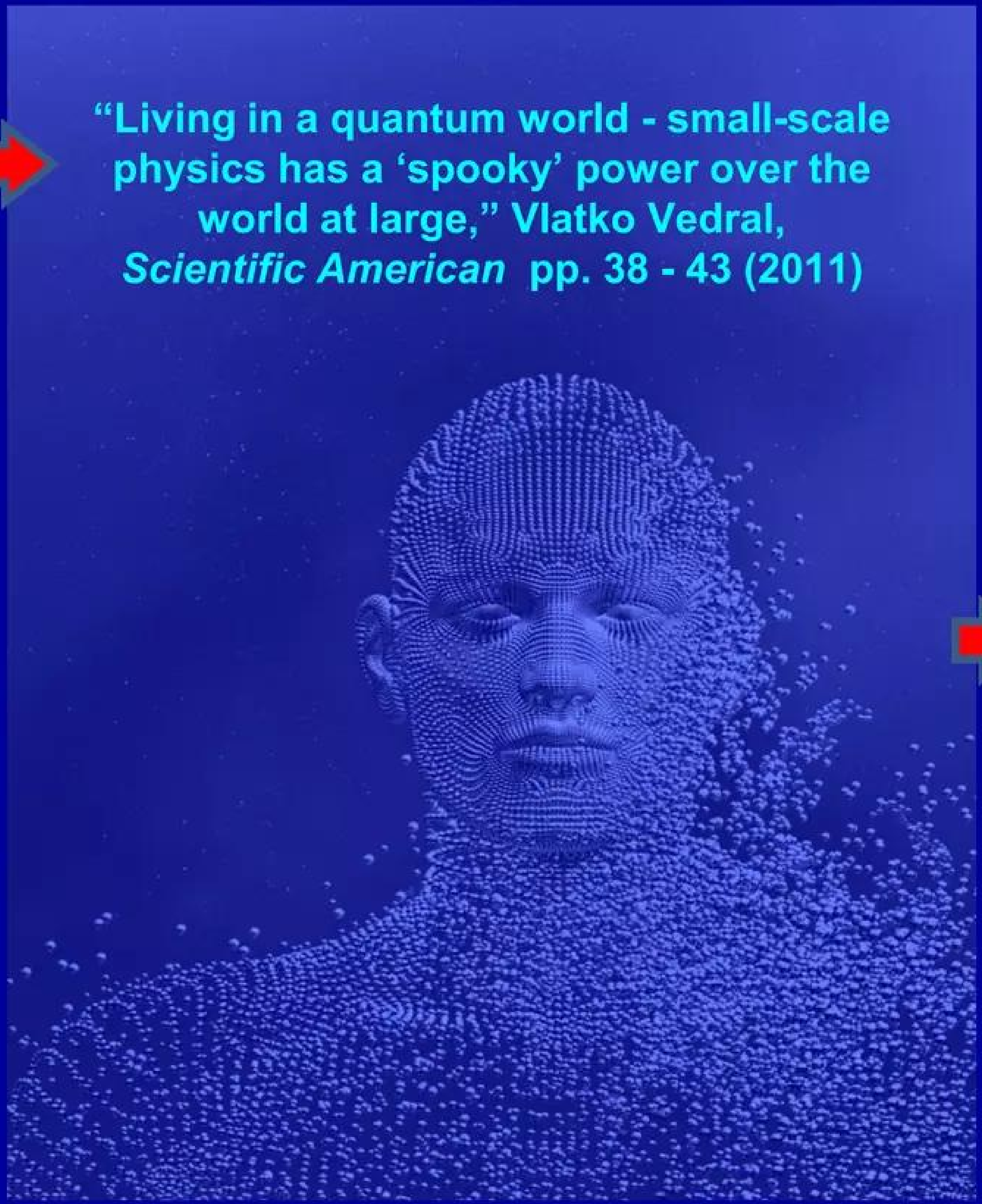


Image credit : Kenn Brown, Mondolithic Studios
Cover of *Scientific American* June 2011

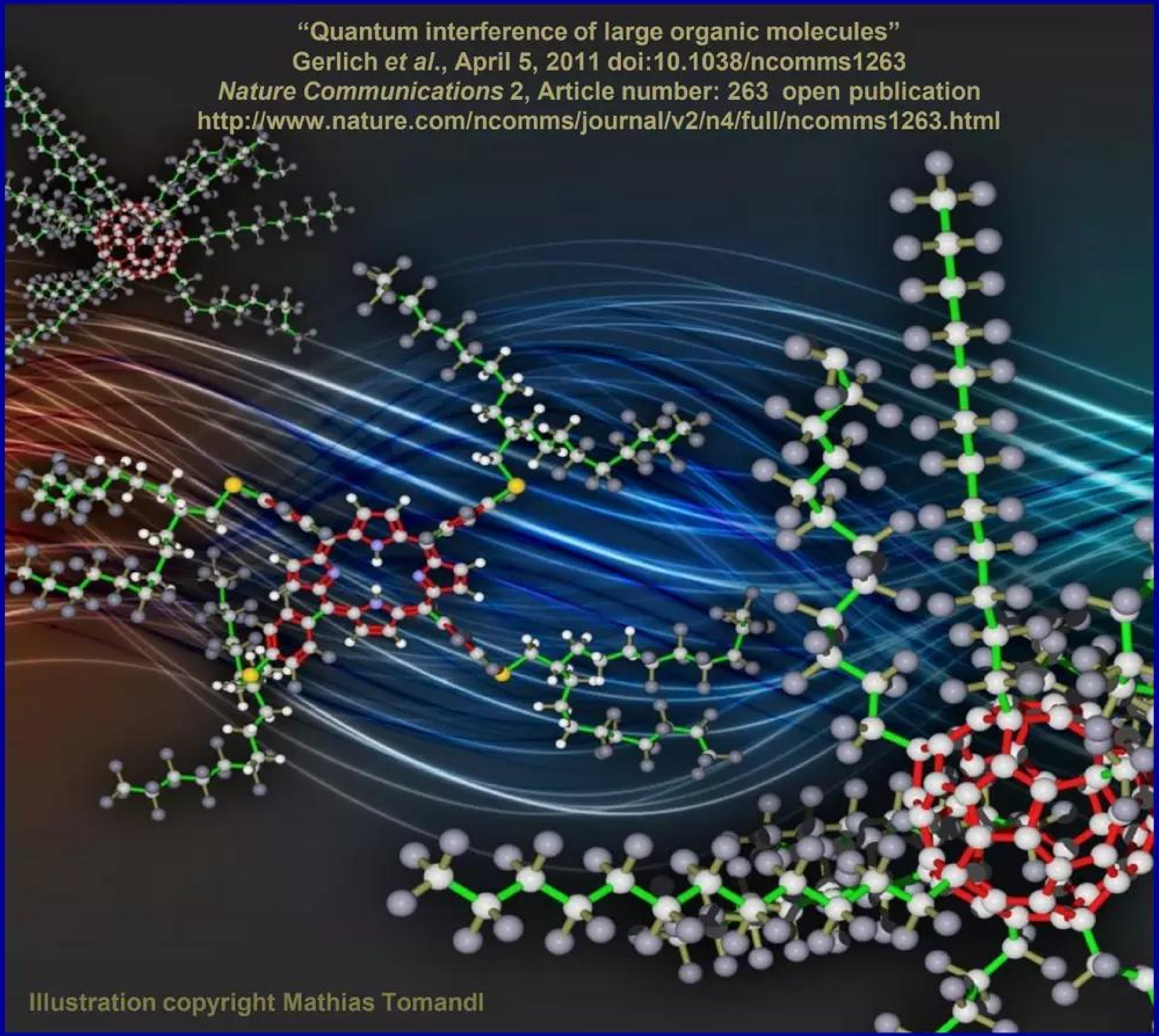
"Not only is the universe stranger than we imagine, it is stranger than we *can* imagine."

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

Many-body collective effects are commonplace in Nature

Certain quantum mechanical effects are key to LENRs in realm of condensed matter

"PFNS10 and TPPF152 contain 430 atoms covalently bound in one single particle. This is ~350% more than that in all previous experiments and it compares well with the number of atoms in small Bose–Einstein condensates (BEC), which, of course, operate in a vastly different parameter regime: The molecular de Broglie wavelength λ_{dB} is about six orders of magnitude smaller than that of ultracold atoms and the internal molecular temperature exceeds typical BEC values (T<1 μK) by about nine orders of magnitude. Although matter wave interference of BECs relies on the de Broglie wavelength of the individual atoms, our massive molecules always appear as single entities."



Artistic view of most complex and massive molecules (PFNS-10, TPP-152) brought to quantum interference by Gerlich *et al.* (2011)

"Our experiments prove the quantum wave nature and delocalization of compounds composed of up to 430 atoms, with a maximal size of up to 60 Å, masses up to m=6,910 AMU and de Broglie wavelengths down to $\lambda_{dB}=h/mv\simeq 1$ pm ... In conclusion, our experiments reveal the quantum wave nature of tailor-made organic molecules in an unprecedented mass and size domain. They open a new window for quantum experiments with nanoparticles in a complexity class comparable to that of small proteins, and they demonstrate that it is feasible to create and maintain high quantum coherence with initially thermal systems consisting of more than 1,000 internal degrees of freedom."

Many-body collective effects are commonplace in Nature

- ✓ Many-body collective oscillations and mutual quantum entanglement of protons (as well as deuterons and tritons) and electrons (e.g., SPs on metallic hydride surfaces), in conjunction with a breakdown of the Born-Oppenheimer approximation, appear to be relatively common in nature, occurring in many different condensed matter systems
- ✓ While these many-body collective processes chronicled by Chatzidimitriou-Dreismann *et al.* operate very rapidly and nanoscale coherence can only persist for time spans on the order of femtoseconds (10^{-15} sec) to attoseconds (10^{-18} sec), nuclear processes such as weak interaction ULM neutron production and neutron capture operate on even faster time-scales: 10^{-19} to 10^{-22} sec. Therefore, LENRs as explained by the Widom-Larsen theory can easily take advantage of such many-body collective quantum effects as an integral part of their amazing dynamical repertoire
- ✓ It is well-known that metallic surface nanostructures and SP electrons can have configurations that are able to effectively absorb E-M energy over a wide area, transfer and concentrate it, and in conjunction with contiguous surface 'patches' of collectively oscillating protons, create extremely high local electric fields. According to W-L theory, ULM neutron production may then follow

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

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

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

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

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

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Collective many-body nuclear effects occur in two realms

W-L condensed matter electromagnetic realm: mainly $e^{-*} + p^{+} \rightarrow n + \nu_e$ followed by n captures

- ✓ Substantial quantities of Hydrogen isotopes must be brought into intimate contact with 'fully-loaded' metallic hydride-forming metals; e.g., Palladium, Platinum, Rhodium, Nickel, Titanium , Tungsten, etc.; please note that collectively oscillating, 2-D surface plasmon (SP) electrons are intrinsically present and cover the surfaces of such metals. At 'full loading' of H, many-body, collectively oscillating '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 very similarly to SPs; when such molecules are hydrogenated, they can create many-body, collectively oscillating, 'entangled' quantum systems that, within context of W-L theory, are functionally equivalent to loaded metallic hydrides
- ✓ Born-Oppenheimer approximation breaks down in tiny surface 'patches' of contiguous collections of collectively oscillating p^+, d^+, and/or t^+ ions; enables E-M coupling between nearby SP or π electrons and hydrogen ions at these locations --- *creates local nuclear-strength electric fields*; effective masses of coupled electrons are then increased to some multiple of an electron at rest ($e \rightarrow e^*$) determined by required simultaneous energy input(s)
- ✓ System <u>must</u> be subjected to external non-equilibrium fluxes of charged particles or E-M photons that are able to transfer input energy directly to many-body SP or π electron 'surface films.' Examples of such external energy sources include (they may be used in combination): electric currents (electron 'beams'); E-M photons (e.g., emitted from lasers, IR-resonant E-M cavity walls, etc.); pressure gradients of p^+, d^+, and/or t^+ ions imposed across 'surfaces'; currents of other ions crossing the 'electron surface' in either direction (ion 'beams'); etc. Such sources provide additional input energy that is required to surpass certain minimum H-isotope-specific electron-mass thresholds that allow production of ULM neutron fluxes via $e^* + p^+$, $e^* + d^+$, or $e^* + t^+$ weak interactions

WLS plasma electromagnetic realm: mainly $e^- + p^+ \rightarrow lepton + X$ and on dust grains $e^{-*} + p^+ \rightarrow n + \nu_e$

- ✓ At minimum, one needs protons (p^+ Hydrogen) and electrons embedded in organized magnetic fields with variable geometries; this is what we call the "WLS magnetic field regime on large length scales" --- it involves transfers of energy between collections of charged particles via magnetic fields (high, short-range electric fields not important). When charged nanoparticles (dust grains) are also present within a plasma (dusty plasma) condensed matter ULM neutron LENRs may occur on dust surfaces in parallel with plethora of high-energy charged particle reactions in gas

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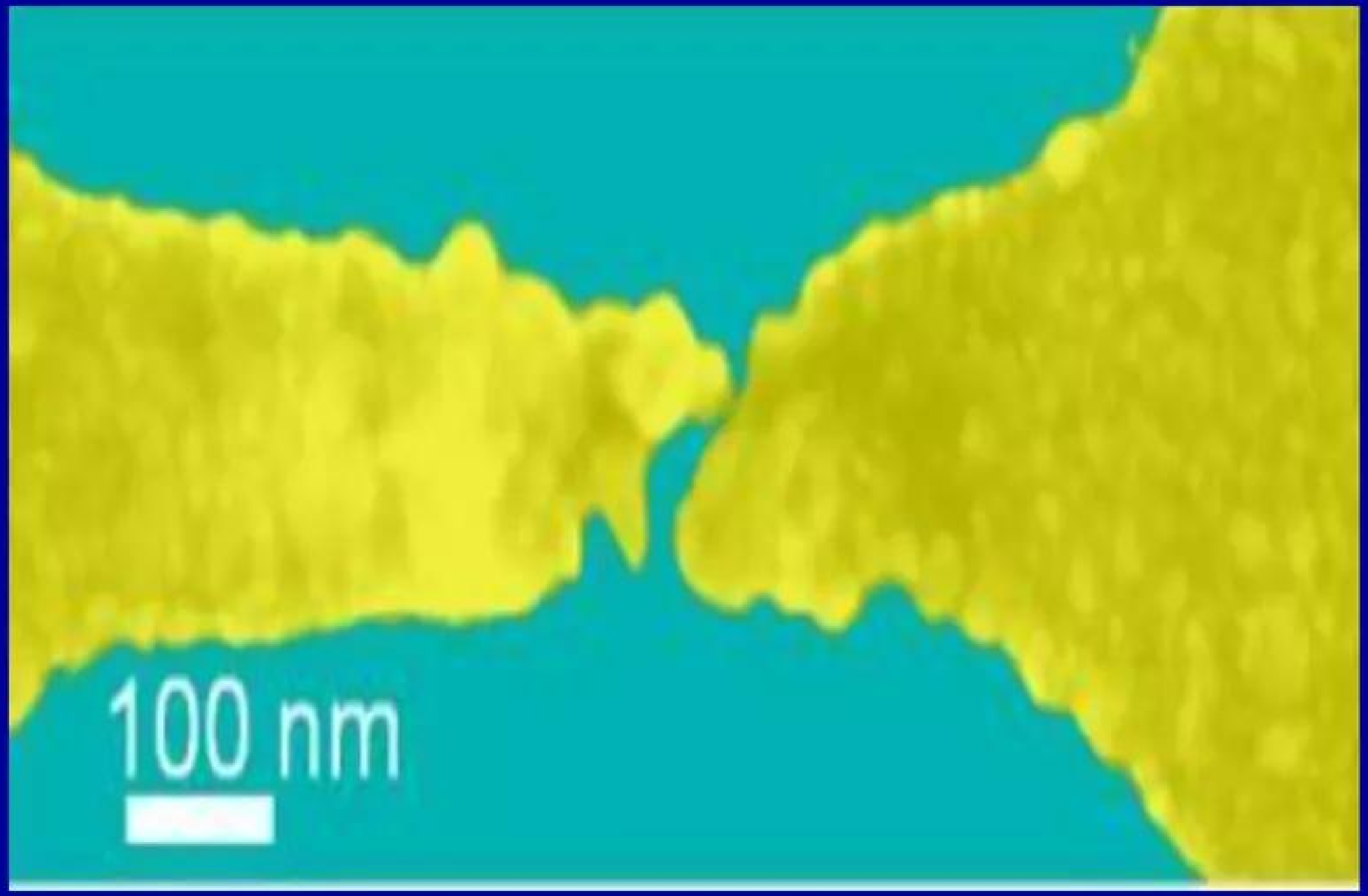
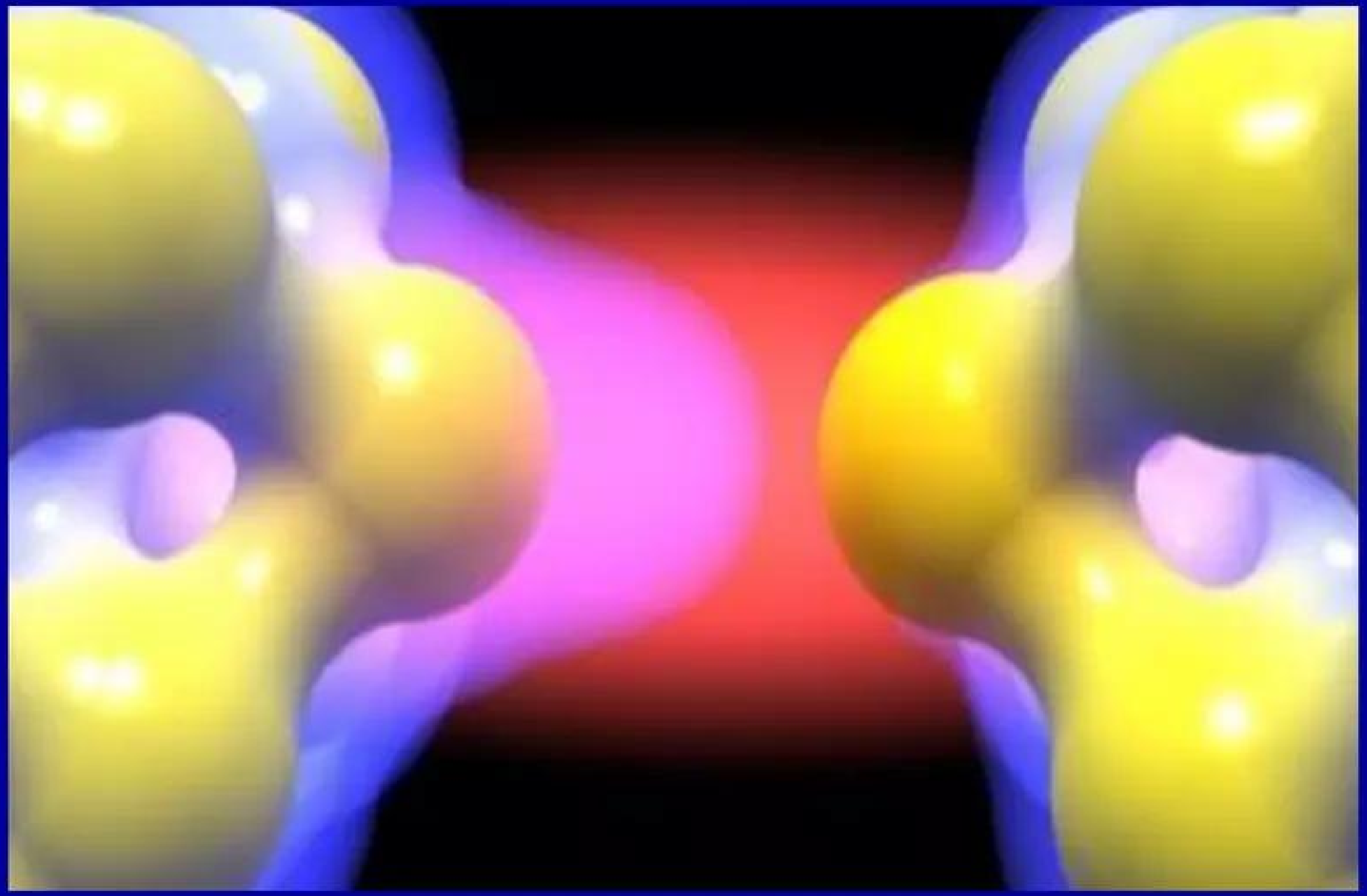
Condensed matter realm: LENR-active surfaces on dust

Time-varying E-M, chemical, and nuclear processes operate together

Artist's rendering (right) shows how surface plasmons on the surface of a pair of nanoscale gold (Au) nanotips (SEM image to left) concentrate incident light from a commercial laser, amplifying it locally by a factor of 1,000x



Credit: Natelson Lab/Rice University



Credit: Natelson Lab/Rice University

Reference for two above images: "Optical rectification and field enhancement in a plasmonic nanogap," D. Ward et al., *Nature Nanotechnology* 5 pp. 732–736 (2010)

"Metal nanostructures act as powerful optical antennas because collective modes ... are excited when light strikes the surface ... [their] plasmons can have evanescent electromagnetic fields ... orders of magnitude larger than ... incident electromagnetic field ... largest field enhancements ... occur in nanogaps between ... nanostructures."

Similarly: "Extraordinary all-dielectric light enhancement over large volumes," R. Sainidou et al., *NANO Letters* 10 pp. 4450–4455 (2010)

" ... allow us to produce arbitrarily large optical field enhancement using all dielectric structures ... measure the enhancement relative to the intensity of the incident light. ... if absorption losses are suppressed, resonant cavities can pile up light energy to create extremely intense fields ... no upper bound to the intensity enhancement factor that these structures can achieve ...[certain factors] limit it to around 4 orders of magnitude in practice."

Condensed matter realm: LENR-active surfaces on dust

Time-varying E-M, chemical, and nuclear processes operate together

- ✓ **LENR 'hot spots' create intense local heating and variety of surface features such as 'craters'; over time, LENR-active surfaces experience major micron-scale changes in nanostructures/composition. On LENR-active substrate surfaces, there are a myriad of different complex, nanometer- to micron-scale electromagnetic, chemical, and nuclear processes *operating in parallel.* LENRs involve interactions between surface plasmons, E-M fields, and many different types of nanostructures with varied geometries, surface locations relative to each other, and chemical/isotopic compositions**

- ✓ **To greater or lesser degrees, many of these very complex, time-varying surface interactions are electromagnetically coupled on many different physical length-scales; E-M resonances are important**

- ✓ **Surface plasmons and their interactions with nanostructures/nanoparticles enable physics regime that permits LENRs to occur in condensed matter systems under relatively mild *macroscopic* conditions (cores of stars, fission reactors, or supernovas are not required). In concert with many-body, collective Q-M effects, SPs also function as two-way 'transducers,' effectively interconnecting the otherwise rather distant realms of chemical and nuclear energies**

- ✓ **Please be aware that a wide variety of complex, interrelated E-M phenomena may be occurring simultaneously in parallel in different nm to μ-scale local regions on dust grain surfaces. Some regions may be absorbing E-M energy locally, while others nearby can be emitting energy (e.g., as energetic electrons, photons, other charged particles, etc.). At the same time, energy can be transferred from regions of resonant absorption or 'capture' to other regions in which emission or 'consumption' is taking place: e.g., photon or electron emission, and/or LENRs in which [E-M field energy] + $e^- \rightarrow e^{-*} + p^+ \rightarrow n_{ulm} + \nu$ --- in LENRs, electrons and protons (particles) are truly destroyed!**

WLS nucleosynthesis can occur in plasmas and on dust

High energy particle reactions occur in plasmas and LENRs on condensed matter dust partciles

- Stars – additional nuclear reactions occur in photospheres and out thru coronas
- Dusty, hydrogen-rich nebular 'clouds' commonly found in star-forming regions
- Magnetars & active galactic nuclei (W-L-S mechanism creates UHE cosmic rays)

- ✓ Very dusty, hydrogen-rich nebular 'clouds' found in star-forming regions of galaxies provide a comparatively low-energy, less ionized astrophysical environment in which an array of carbon-based molecules can coexist in abundance. Within these comparatively dense, somewhat opaque 'clouds,' carbon-based moieties coexist with hydrogen and are intimately associated with dust particles (which themselves contain a wide variety of elements, including many metals)
- ✓ All of this matter is periodically bathed in varying amounts of stellar photon radiation ranging from infrared to ultraviolet wavelengths; in some cases, it is also directly exposed to streams of charged particles, e.g., protons from stellar 'winds.' Some astrophysicists even believe that huge lightning bolts occur inside such clouds; may also happen in atmospheres of gas giant planets
- ✓ Astronomers have detected large quantities of PAHs, e.g., Phenanthrene, in such star-forming regions; many believe that PAHs are actually synthesized therein through an interaction of energetic photon radiation with simpler carbon structures on dust surfaces
- ✓ While hydrogen gas pressures are vastly lower in such stellar nurseries, physical conditions inside them otherwise resemble Mizuno's Phenanthrene experiments in many key ways. If that analogy is proper, then W-L theory would predict that LENR nucleosynthesis can occur there

LENRs occur on dust in many parts of the Universe

"The composition, structure, and size distribution of interstellar grains is the result of injection of dust from stellar outflows into the interstellar medium (ISM), followed by destruction, growth, coagulation, and photoprocessing of interstellar grains. The balance among these poorly-understood processes is responsible for the mix of solid material present in the ISM. **Most interstellar grain material present in the diffuse ISM must be grown *in* the ISM**. The amorphous silicate and carbonaceous materials that form the bulk of interstellar dust must therefore be the result of grain growth in the presence of ultraviolet radiation. **Dust in high-Z systems such as J1148+5251 is also produced primarily in the ISM, with supernova-produced dust contributing only a small fraction of the total dust mass."**

"The wavelength-dependent extinction of starlight – the so-called "extinction curve" – remains the principal source of information about interstellar dust ... The extinction curve contains spectral features that constrain the composition of the dust. The strongest feature by far is a broad "bump" peaking near 2175°A. The strength of this feature requires that it be produced by a substance composed of high-abundance elements, such as C, Mg, Si, or Fe (Draine 1989). The position of the feature, and its width, are strongly suggestive of π -> π^* excitations in aromatic carbon, such as graphite or polycyclic aromatic hydrocarbons. Some authors (e.g., Draine & Li 2007) think that the **feature is produced by the large population of polycyclic aromatic hydrocarbons that is required to explain a number of infrared emission features."**

"Large a > 0.02μm grains in the local starlight background will be heated to a more-or-less steady temperature of 15 - 20K. However, very small grains (1) absorb photons much less frequently, and (2) have very small heat capacities, so that one absorbed photon can raise the grain to a high temperature, followed by very rapid cooling …. Perhaps 2/3 of C is in dust … There is a substantial population of PAHs that contains ~10–20% of the interstellar C in the Milky Way; ~4 - 5% of the total grain mass is contributed by PAHs in the Milky Way and other star-forming galaxies with ~solar metallicity (Draine et al. 2007) … ***Most interstellar dust is not stardust*** … Stardust accounts for only ~4% of the total mass of interstellar dust … *Most of the material in interstellar grains was formed in the ISM* … . The resulting grain material(s) will undergo heavy UV irradiation … Hydrogenation … This surface site is being bombarded by H atoms at a rate …Observations of quasars and luminous galaxies at high redshift have detected large masses of dust in a number of systems (Wang et al. 2008) …Grain destruction in the ISM is such that ~<10% of the interstellar dust mass consists of "stardust" from stellar sources, including supernovae. ***The bulk of interstellar dust has been grown in the ISM.*** " **[per WLS, LENRs can occur in such systems]**

B. T. Draine, "Interstellar Dust Models and Evolutionary Implications," arXiv:0903.1658v1 [astro-ph.GA] 9 Mar 2009

See: http://arxiv.org/PS_cache/arxiv/pdf/0903/0903.1658v1.pdf

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W-L and WLS theory extend from microcosm to macrocosm

Many-body collective effects occur from nano up to very large length-scales

Electromagnetic regimes encompass realms of condensed matter and certain plasmas

Short-range collective electric field effects dominate

Longer-range collective magnetic field effects begin to dominate

Long-range collective magnetic field effects dominate

Length Scale	Type of System	Electromagnetic Regime	Collective LENR Phenomena	Comment
Submicron	Certain earthly bacteria and fungi	Very short-range electric or magnetic fields	Transmutations, high level gamma shielding	Obtain unavailable trace elements; survive deadly gamma/X-ray radiation
Microns	Hydrogen isotopes on metallic surfaces	Very high, short-range electric fields on solid substrates	Transmutations, high level gamma shielding, heat, some energetic particles	This regime is useful for small-scale commercial power generation
Microns to Many Meters	Exploding wires, planetary lightning	Dusty plasmas: mixed high-current and high local magnetic fields	Transmutations, 'leakier' gamma shielding, heat; X-rays up to 10 keV, larger energetic particle fluxes	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	Transmutations, large fluxes of energetic particles (to GeVs), limited gamma shielding, X-rays	Solves mysteries of heating of solar corona and radioactive isotopes in stellar atmospheres
Up to several AU (distance from earth to sun)	Active galactic nuclei in vicinity of compact, massive objects (black holes)		Energetic particles (GeVs), gamma-ray bursts (GRBs) and ultra-high energy cosmic rays (TeVs)	Solves several unexplained astronomical mysteries

Increasing neutron and charged particle energies

N.B. - mass renormalization of electrons by high local E-fields *not* a key factor in magnetically dominated regimes on large length scales

Commercializing a next-generation source of CLENR energy

Neutron/charged particle energies range from ULM to TeVs

Short-range collective electric field effects dominate

Longer-range collective magnetic field effects begin to dominate

Long-range collective magnetic field effects dominate

Regime of mostly low energy nuclear reactions: LENRS dominate

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

Neutron production & capture release energy, create transmutation products

Low or no current

- 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
- RF-triggered dusty plasmas - gas phase

High current

- 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
- 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

WLS mixed regime: high energy particle reactions and/or LENRs on 'dust'

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

Mega currents

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

>>> fluxes

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

Increasing neutron and charged particle energies

Commercializing a next-generation source of CLENR energy

Selected technical publications discussed herein

"***Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces***" Eur. Phys. J. C **46**, pp. 107 (March 2006) Widom and Larsen – initially placed on arXiv in May 2005 at http://arxiv.org/PS_cache/cond-mat/pdf/0505/0505026v1.pdf; a copy of the final *EPJC* article can be found at: http://www.newenergytimes.com/v2/library/2006/2006Widom-UltraLowMomentumNeutronCatalyzed.pdf
"***Absorption of nuclear gamma radiation by heavy electrons on metallic hydride surfaces***" http://arxiv.org/PS_cache/cond-mat/pdf/0509/0509269v1.pdf (Sept 2005) Widom and Larsen
"***Nuclear abundances in metallic hydride electrodes of electrolytic chemical cells***" http://arxiv.org/PS_cache/cond-mat/pdf/0602/0602472v1.pdf (Feb 2006) Widom and Larsen
"***Theoretical Standard Model rates of proton to neutron conversions near metallic hydride surfaces***" http://arxiv.org/PS_cache/nucl-th/pdf/0608/0608059v2.pdf (v2. Sep 2007) Widom and Larsen
"***Energetic electrons and nuclear transmutations in exploding wires***" http://arxiv.org/PS_cache/arxiv/pdf/0709/0709.1222v1.pdf (Sept 2007) Widom, Srivastava, and Larsen
"***Errors in the quantum electrodynamic mass analysis of Hagelstein and Chaudhary***" http://arxiv.org/PS_cache/arxiv/pdf/0802/0802.0466v2.pdf (Feb 2008) Widom, Srivastava, and Larsen
"***High energy particles in the solar corona***" http://arxiv.org/PS_cache/arxiv/pdf/0804/0804.2647v1.pdf (April 2008) Widom, Srivastava, and Larsen
"***A primer for electro-weak induced low energy nuclear reactions***" Srivastava, Widom, and Larsen Pramana – Journal of Physics **75** pp. 617 (October 2010) http://www.ias.ac.in/pramana/v75/p617/fulltext.pdf

Nucleosynthesis in exploding wires and lightning - I

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

- ✓ **Summarizes results of all of our other technical publications about WLS theory at a lower level of mathematical detail; more conceptually oriented. Since WLS impinges many areas of study, readers are urged to start with the *Prime*r and then examine details in other papers as dictated by specific interests**
- ✓ **Focusing on lightning-related phenomena, we will now draw attention to selected aspects of the *Primer***
- ✓ **Please note that in magnetically organized lightning plasmas (which typically occur on relatively large length-scales, as opposed to nanometers to microns for LENR processes in condensed matter) WLS theory involves many-body collective magnetic effects. Note that under these conditions, neutrons produced via weak interactions per WLS theory are not necessarily ultra low momentum (ULM). For example, in stars' magnetic flux tubes and more violent events like solar flare 'explosions', neutrons and a variable array of particles (e.g., protons, positrons) may be created at very high energies ranging all the way up to 500 GeV and even beyond in the case of flux tubes in accretion disks surrounding black holes**
- ✓ **In case of dusty plasmas inside lightning channels in regions where average temperatures are such that intact embedded dust grains or nanoparticles (which may be strongly charged) can exist for a time therein, W-L condensed matter LENRs producing ~ULM neutrons may also occur on the surfaces of such particles**
- ✓ **Quoting from the conclusions: "Three seemingly diverse physical phenomena, viz., metallic hydride cells, exploding wires and the solar corona, do have a unifying theme. Under appropriate conditions which we have now well delineated, in all these processes electromagnetic energy gets collectively harnessed to provide enough kinetic energy to a certain fraction of the electrons to combine with protons (or any other ions present) and produce neutrons through weak interactions. The produced neutrons then combine with other nuclei to induce low-energy nuclear reactions and transmutations."**

Nucleosynthesis in exploding wires and lightning - II

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

- ✓ **pp. 621:** "We can write it in a more useful (system of unit independent) form using the Alfven current $I_0 \approx 17$ kA, which was defined in eq. (4) ... Thus, we see that even with a moderate $(v/c) \approx 0.10$, if currents are much larger than the Alfven value [that is, electron currents >17 kA [i.e., >17,000 Amperes] flowing through a conductor with a cylindrical geometry, i.e., like a wire], the chemical potential can be of the order of MeVs or higher. **This is an example of how the collective magnetic kinetic energy can be distributed to accelerate a smaller number of particles with sufficient energy to produce neutrons."**

- ✓ **pp. 629:** "A typical electron in the current with a mean kinetic energy of 15 keV would have an average speed $(v/c) \approx 0.25$. On the other hand, even for such low mean speed, the chemical potential given in eq. (11), for $(I/I_0) \approx 200$ becomes large $\mu \approx (mc^2)(200)(0.25) = 25$ MeV; (55) [which is] comfortably sufficient for an electron to induce a weak interaction LENR. Overall energy conservation will of course require that **only a certain fraction of about (15 keV/25 MeV) = 6 x 10^{-4} of the total number of electrons in the current will be kinematically allowed to undergo weak interactions."**

- ✓ **Comment:** on Earth, bolts of lightning have a duration of 30 - 50 microseconds and are well-known to involve electrical current pulses on the order of 30,000 to 100,000 Amperes (3 x 10^4 A to 1 x 10^5 A --- N.B. 'superbolts' on Jupiter are 10x larger). Importantly, such values for peak current easily exceed a key threshold identified in our theoretical work, $I_o \approx$ **17,000 Amperes**.

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Nucleosynthesis in exploding wires and lightning - III

Exploding wires and lightning with embedded particles are dusty plasmas

Presence of particles can significantly alter charged particle equilibrium --- non-Hamiltonian systems

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

Abstract (arXiv 2007): "Nuclear transmutations and fast neutrons have been observed to emerge from large electrical current pulses passing through wire filaments which are induced to explode. The nuclear reactions may be explained as inverse beta transitions of energetic electrons absorbed either directly by single protons in Hydrogen or by protons embedded in other more massive nuclei. The critical energy transformations to the electrons from the electromagnetic field and from the electrons to the nuclei are best understood in terms of coherent collective motions of the many flowing electrons within a wire filament. Energy transformation mechanisms have thus been found which settle a theoretical paradox in low energy nuclear reactions which has remained unresolved for over eight decades. It is presently clear that nuclear transmutations can occur under a much wider range of physical conditions than was heretofore thought possible."

Dusty plasma: is a plasma containing nanometer or micrometer-sized particles suspended in it. Dust particles may be charged and the plasma and particles behave as a plasma, following electromagnetic laws for particles up to about 10 nm (or 100 nm if large charges are present). Dust particles may form larger particles resulting in "grain plasmas"

Dust plasma component	Temperature
Dust temperature	10 K
Molecular temperature	100 K
Ion temperature	1,000 K
Electron temperature	10,000 K

See: http://en.wikipedia.org/wiki/Dusty_plasma

Temperature of dust in a plasma may be quite different from its environment (for example, see Table to left). If relativistic electrons are actually charging dust gains, then the dust may charge up to several kilovolts. Field electron emission (reduces negative potential) can be important due to the small size of the particles; E-field gradients can be >> 1,000 Volts per micron!

Nucleosynthesis in exploding wires and lightning - IV

Exploding wires and lightning with embedded particles are dusty plasmas

- ✓ **Quoting from our arXiv preprint: "Over eighty years ago, Wendt and Irion[1] reported nuclear reactions in exploding wires. The transmuted nuclear products emerged after a large current pulse was passed through a Tungsten wire filament which exploded. Sir Ernest Rutherford[2] expressed doubts as to whether the electrons flowing through the wire could carry enough energy to induce nuclear reactions. The exploding wire current pulse had been produced by a capacitor discharge with an initial voltage of only thirty kilovolts. On the other hand, Rutherford had employed a high energy but dilute beam of 100 KeV electrons fired into a Tungsten target. Rutherford did not observe any nuclear reactions. Wendt[3] replied to the Rutherford objections, asserting that the peak power in the exploding wire current pulse was much larger than the relatively small power input to Rutherford's electron beam. Most importantly, a large energy transfer from the many electrons in the wire to the nuclei could occur collectively which would allow for the nuclear transmutation energy."**

- ✓ **"This very old but important debate between Wendt and Rutherford has presently been experimentally settled in favor of Wendt. The more recent [4, 5, 6, 7, 8, 9] exploding wire experiments have, beyond any doubt, detected fast emerging neutrons capable of inducing nuclear transmutations. These observed fast neutrons have often been attributed to the products of deuteron fusion but we find that hypothesis unlikely to be true. Firstly, fast neutrons have been seen in exploding wires even though there were no deuterons initially present [4, 5]. Secondly, the [~23 MeV] gamma emission signature of deuterium fusion has not been observed. It is much more likely that the fast neutrons are products of inverse beta transitions of very energetic electrons being absorbed by protons and producing fast neutrons and neutrinos. The protons may be Hydrogen atomic nuclei or the protons may be embedded within more massive nuclei... theoretical side of the difference of opinion between Wendt and Rutherford concerning how large amounts of energy can be transferred to and from the electrons in the wire has remained unresolved... purpose [herein] is to explain how this collective energy transfer may occur."**

Nucleosynthesis in exploding wires and lightning - V

Exploding wires and lightning with embedded particles are dusty plasmas

- ✓ Quoting from our arXiv preprint: "The scale of wire currents required to induce nuclear reactions may be found by expressing the rest energy of the electron mc^2 in units of a current I_o; i.e. by employing the vacuum impedance R_{vac} one finds $I_o \approx 1.704509 \times 10^4$ Ampere"

- ✓ "If a strong current pulse, large on the scale of I_o, passes through a thin wire filament, then the magnetic field exerts a very large Maxwell pressure on surface area elements, compressing, twisting and pushing into the wire. If the magnetic Maxwell pressure grows beyond the tensile strength of the wire material at the hot filament temperature, then the wire begins to melt and disintegrate. If the heating rate is sufficiently fast, then the hot wire may emit thermal radiation at a very high noise temperature. The thermal radiation for exploding Tungsten filaments exhibits X-ray frequencies indicating very high electron kinetic energies within the filament. Due to the electron kinetic pressure, the wire diameter starts to increase yielding a filament dense gas phase but still with some liquid droplets. The final explosive product consists of a hot plasma colloid containing some small dust particles of the original wire material. These products cool off into a gas and some smoke as is usual for explosions."

- ✓ "A change in the collective current dI yields a changing single electron momentum and thereby a change in the single electron energy dW wherein v is the velocity of that electron. The single electron energy can thereby reach values far above the electron rest energy for a pulse peak current large on the scale of I_o."

- ✓ "Many electrons acting cooperatively contribute energy $W_{magnetic}$ to inverse beta transitions even though only one of those electrons is destroyed. The Wendt-Irion peak current ratio I/I_o was as high as two hundred [3] yielding $W_{magnetic}$ ~200 MeV x v/c. If the electron velocity in the filament is small, say $v/c \sim 0.1$, then $W_{magnetic}$ is more than sufficient for an inverse beta transition."

Nucleosynthesis in exploding wires and lightning - VI

Exploding wires and lightning with embedded particles are dusty plasmas

- ✓ Quoting from our arXiv preprint: "The following comments are worthy of note: (*i*) The electromagnetic field configuration when the current pulse passes through the wire is a magnetic field tangent to the wire surface and normal to the wire axis and an electric field parallel to the cylinder. This is the low circuit frequency limit of the surface plasma polariton mode previously employed in the explanation [11] of inverse beta transitions in chemical cells. However, the natural surface patches whereon the long wavelength neutrons would form are in the case of thin wire filaments destroyed by the explosion. (*ii*) Radiation losses have not been included in the above discussion. These losses are not large because of the collective nature of the current."

- ✓ "A single charged accelerating particle emits copious radiation whereas many electrons contributing to a smooth current in a wire will hardly radiate at all. However, some resistive wire heating energy will be removed from the wire filament as hot emitted thermal radiation. (*iii*) The Maxwell electromagnetic energy and pressure are largely due to the Ampere's law mutual attraction between electrons moving in the same direction. When an electron is combined with a proton to produce a neutron and a neutrino, the required energy is in part the attractive energy due to all of the other parallel moving electrons in the wire albeit only one electron is actually destroyed."

- ✓ Quoting from *Pramana* (2010): "A typical electron in the current with a mean kinetic energy of 15 keV would have an average speed $(v/c) \approx 0.25$. On the other hand, even for such low mean speed, the chemical potential given in eq. (11), for $(I/I_o) \approx 200$ becomes large $\mu \approx (mc^2)(200)(0.25) = 25$ MeV; (55) comfortably sufficient for an electron to induce a weak interaction LENR. Overall energy conservation will of course require that only a certain fraction of about (15 keV/25 MeV) = 6×10^{-4} of the total number of electrons in the current will be kinematically allowed to undergo weak interactions. Let us now briefly discuss why Rutherford with his much higher energy ---but dilute --- beam of electrons did not observe any nuclear reactions. The reason is rather simple. In the vacuum, there is a mutual Coulomb repulsion between the electrons in the beam which compensates the mutual Amperian current attraction. In the exploding wire filament, on the other hand, the repulsive Coulomb part is screened by the background positive charge but *leaves intact the Amperian current attraction thereby allowing the possibility of nuclear reactions*."

- ✓ N.B.: above also true for lightning with particles embedded in it and solar flux tubes with proton and electron currents

Commercializing a next-generation source of CLENR energy

New evidence for low energy neutron fluxes in lightning - I

Data consistent with WLS many-body collective magnetic mechanism

"Strong flux of low-energy neutrons produced by thunderstorms," A. Gurevich *et al., Physical Review Letters* **108** pp. 125001 - 4 (March 2012) http://prl.aps.org/abstract/PRL/v108/i12/e125001

Abstract: **"We report here for the first time about the registration of an extraordinary high flux of low-energy neutrons generated during thunderstorms. The measured neutron count rate enhancements are directly connected with thunderstorm discharges.** The low-energy neutron flux value obtained in our work is a challenge for the photonuclear channel of neutron generation in thunderstorm: the estimated value of the needed high-energy γ-ray flux is about 3 orders of magnitude higher than that one observed."

Lattice comments: since 1985 (G. Shah *et al., Nature* **313** pp. 773) experimental reports of correlation between thunderstorm lightning discharges and detection of neutron production have been published episodically in major peer-reviewed journals. However, this new, highly reliable data collected by Russian scientists and published in *Phys Rev Lett* is the first instance in which: (a) observed neutron fluxes associated with lightning discharges could be accurately counted, well-estimated quantitatively, and temporally correlated with lightning discharges; and (b) better insights were achieved into energy spectra of such lightning-produced neutrons. **Importantly, size of the neutron fluxes observed by Gurevich *et al.* are too large to be explained by a photonuclear mechanism (in recent years was thought by many to successfully explain neutron production in lightning channels).**

Given that fusion processes had been decisively excluded in years prior to a recent rise in popularity of the conjectured photonuclear mechanism (e.g., see L. Babich & R. R-Dupre, 2007, discussed herein), the Widom-Larsen-Srivastava (WLS) many-body, collective magnetic $e^- + p^+$ weak-interaction mechanism is the only remaining theoretical approach that can plausibly explain key features of this new data.

New evidence for low energy neutron fluxes in lightning - II

Data consistent with WLS many-body collective magnetic mechanism

"Strong flux of low-energy neutrons produced by thunderstorms," A. Gurevich *et al., Physical Review Letters* **108** pp. 125001 - 4 (March 2012) http://prl.aps.org/abstract/PRL/v108/i12/e125001

Quoting directly: "**The neutrons if generated in atmospheric discharge processes are expected to have low energies.** For example being born in photonuclear channel near the threshold they would have energies of a few MeV and less due to collisional losses. The NM [neutron monitor] sensitivity in this energy range is very low. So, it is more appropriate to use the low-energy neutron detectors simultaneously with NM. **We inform here for the first time about the registration of the extremely intensive fluxes of low-energy neutrons generated during thunderstorms. We also claim that these fluxes are connected with atmospheric discharges.** Observations were performed at the Tien-Shan Mountain Cosmic Ray Station, Kazakhstan (altitude 3340 m) during 17 thunderstorms in the summer 2010."

Experimental setup: "Low-energy environmental neutron flux around the Tien-Shan Station was measured by a set of three thermal neutron detectors (TND) based on the 'Helium-2' - type proportional neutron counters. These detectors are 1.2 x 0.84 m^2 aluminum boxes each containing six 1 m long, 3 cm in diameter neutron counters. The counters are filled with the gaseous ^{3}He under the pressure of 2 atmospheres, so the neutron registration in the low energy range succeeds due to the reaction ^{3}He $(n, p)t$ with an efficiency of about 60%."

"According to the specification the counter registers both thermal neutrons having energies from 0.01 up to 0.1 eV and neutrons having energies from 0.1 up to 1 eV with the equal efficiency. At the higher energies the efficiency falls down and become three orders lower at the neutron energy 10 keV. TNDs register the neutrons having the energies less than few keV and they are fully insensitive to the high energy hadrons flux of the cosmic ray origin."

New evidence for low energy neutron fluxes in lightning - III

Data consistent with WLS many-body collective magnetic mechanism

"Strong flux of low-energy neutrons produced by thunderstorms," A. Gurevich *et al., Physical Review Letters* **108** pp. 125001 - 4 (March 2012) http://prl.aps.org/abstract/PRL/v108/i12/e125001

Experimental setup (continued - 2):

"One of TNDs - an 'external' one, is placed in the open air inside a light plywood housing at the distance 15 m from other two detectors. An 'internal' detector is placed in the room screened from the top by a thin (2 mm) roofing iron ceiling and a 20 cm carbon layer. The third one, an 'underfloor' is placed under wooden 4 cm floor of the same room and is additionally shielded from the top by a 3-cm-thick layer of rubber."

"Registration of the hadronic cosmic ray component, including the high-energy neutrons was performed by a standard 18NM64 type neutron supermonitor placed in the same room as the internal detector. The NM consists of three separate units. Each unit contains six SNM15 type proportional neutron counters, 150 mm in diameter and 2 m in the length. The energy response of the NM64 neutron supermonitor was studied both experimentally and with the use of simulation approach. It was found, that the typical energy threshold is about some hundreds of MeV, at which interaction energy the mean number of registered secondary neutrons exceeds 1 which ensures an efficient registration of primary hadron. At the few MeV the registration efficiency of NM falls down from 10% at 3 MeV to 2% at 0.5 MeV. In the energy range less than 100 keV the efficiency remains at the level of 1% diminishing to 0.5% at the thermal energies."

"Output pulses from the NM counters are registered continuously with a 1-minute time resolution (this is a standard in the worldwide net of the cosmic ray intensity variation database which the Tien-Shan supermonitor belongs to). Handling of the output signals from all TNDs is quite the same as for NM: accumulated intensity values are recorded with a 1-min time resolution, separately for each counter."

New evidence for low energy neutron fluxes in lightning - IV

Data consistent with WLS many-body collective magnetic mechanism

"Strong flux of low-energy neutrons produced by thunderstorms," A. Gurevich *et al., Physical Review Letters* **108** pp. 125001 - 4 (March 2012) http://prl.aps.org/abstract/PRL/v108/i12/e125001

Experimental setup (continued - 3):

"Because our installation is destined for operation under a very intensive electromagnetic and acoustic interference on the part of lightning discharges, a special attention was paid to the control of the reliability of its signals. Besides the usual grounding and electromagnetic shielding of the all electric circuits this control includes using of the special ''dummy'' information channels. These are additional neutron counters placed inside the boxes of low-energy detectors which are switched to the data registration system but the high voltage in the feeding main is diminished strongly to exclude the registration of neutrons. All the signals from neutron detectors including dummy ones pass through the discriminators having the same thresholds for all channels. The threshold value is arranged in such a way that it is higher than the electronic circuit noise. The registration system counts pulses of the discriminator output signal. **The number of pulses in dummy channels is found to be zero both in the non-thunderstorm and in the thunderstorm time."**

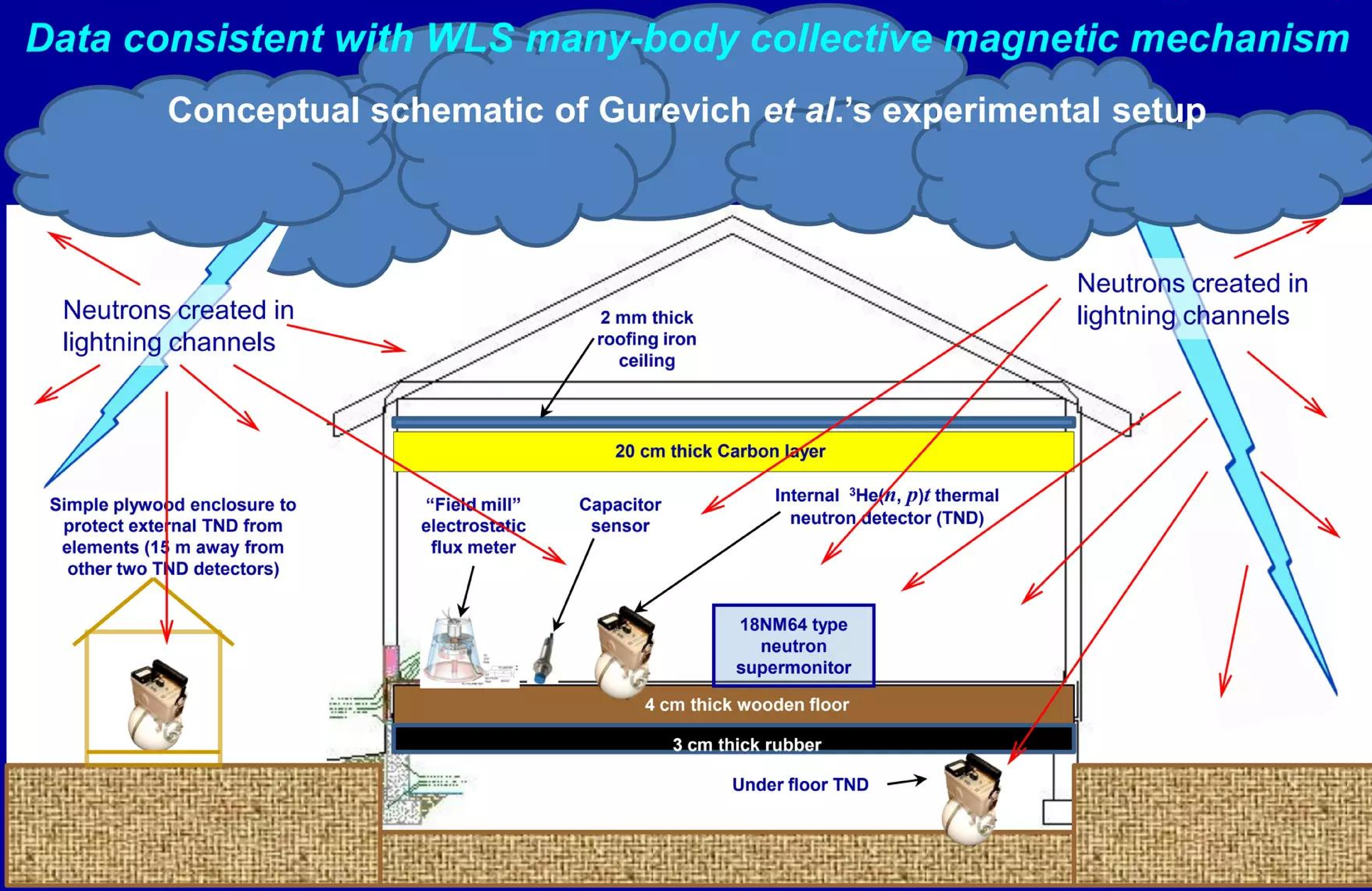
"The quasistatic electric field during the thunderstorm passages is measured with the use of an electrostatic flux meter of the 'field-mill' type which operates with sampling frequency of 1000 Hz, while the fast variation of the electric field in lightning discharges is detected using the capacitor-type sensor. **Both the 'field-mill' and the capacitor sensor are installed in the vicinity of the neutron detector complex**. Additionally, atmospheric discharges were registered using two radio-antenna setups which operate in the frequency range of 0.1 - 30 MHz."

Please see next Slide for a conceptual schematic graphic diagram of Gurevich *et al.*'s experimental setup.

Commercializing a next-generation source of CLENR energy

New evidence for low energy neutron fluxes in lightning - V

Data consistent with WLS many-body collective magnetic mechanism



Commercializing a next-generation source of CLENR energy

New evidence for low energy neutron fluxes in lightning - VI

Data consistent with WLS many-body collective magnetic mechanism

"Strong flux of low-energy neutrons produced by thunderstorms," A. Gurevich *et al., Physical Review Letters* **108** pp. 125001 - 4 (March 2012) http://prl.aps.org/abstract/PRL/v108/i12/e125001

Results of experiments: "In the Fig. 1 it is seen an obvious correlation between the periods of electric discharge and considerable enhancement in the counting rate of low-energy neutrons: in those minutes which overlap with a discharge moment both the external and internal detectors demonstrate an excess of signal intensity up to 2 - 3 times above their mean background levels. The short-time intensity enhancements are also visible in the underfloor detector, though their amplitude here is only about 0.2 - 0.5 above the background, and even in the NM, where the relative enhancement amplitude of 0.02 - 0.05 is noticeable due to its high counting rate. Statistically, the excesses observed during the storms of 10 August in neutron intensity are quite satisfied. **For example in the 13 h event the relative peak amplitudes above the background levels are 63σ, 57σ, 18σ, and 11σ for external, internal, underfloor detectors, and for NM supermonitor correspondingly."**

"On 20 August 2010 a prolonged period of thunderstorm activity at the Tien-Shan Station lasted about 3.5 hours when a number of short-time intensity enhancements of the low-energy neutron signal have been registered. The data recorded during initial phase of thunderstorm are presented in Fig. 2 together with the measurements of electric field. One can see an evident time correlation between the enhancements of neutron flux and atmospheric discharge fixed by the stepwise moments of the electric-field variation. Namely, the enhancements of the neutron counting rate in external and internal TNDs and in NM are in pulses per minute (p.p.m.): 1558, 641, and 804 p.p.m. at 12:54:00, 720, 418, and 1136 p.p.m. at 12:56, 758, 323, and 913 p.p.m. at 12:58 and 2055, 716, and 587 p.p.m. at 13:00. The corresponding atmospheric discharges were fixed at: 12:53:55, 12:55:38, 12:57:41, and 12:59:17. At the same time, any additional neutron flux at TND is absent both before and after the moments of the field change. **Hence, one can declare that the neutrons in every enhancement are generated during the corresponding atmospheric discharge."**

New evidence for low energy neutron fluxes in lightning - VII

Data consistent with WLS many-body collective magnetic mechanism

"Strong flux of low-energy neutrons produced by thunderstorms," A. Gurevich *et al., Physical Review Letters* **108** pp. 125001 - 4 (March 2012) http://prl.aps.org/abstract/PRL/v108/i12/e125001

Results of experiments (continued - 2): "Note, that the same effect is seen in the Fig. 1 as well. Two electric discharges at 08:05:57 and at 08:07:30 correspond to the neutron flux enhancement which is evidently revealed in all detectors. The counting rate growth in the external and internal TNDs and NM are 1673, 927, 2821 p.p.m., and 1225, 922, 2112 p.p.m. correspondingly, similar to the event presented in Fig. 2. Quite analogous correlation of the neutron enhancements with electric discharges is seen in other events. **Taking into account that the atmospheric discharge lasts for a few hundred milliseconds while the neutron detectors have a 1-min time resolution we see that the additional neutron flux generated in every discharge should be really giant!"**

"The flux enhancements of environmental neutrons in the low-energy range similar to those on August 10 and 20 were met regularly in many thunderstorm events observed at the Tien-Shan station. A full statistics of these events for the year 2010 is presented in Table I. **Practically all the events listed in this table demonstrate the presence of a considerable excess of the neutron counting rate in thunderstorm period, especially in the signals of the external and internal detectors of low-energy neutrons.**

Discussion: "Taking into account the geometrical sizes of neutron counters used in our experiment one can conclude that the sum sensitive surface of the supermonitor neutron detectors is 30 times larger then that of the TND. The counting rate enhancement during neutron events is the same (within the 1.5 - 2 times limit) both in the external and the internal TNDs and the supermonitor. Because of the difference in sensitive areas, it follows that the additional neutron flux registered by the TND is 15 - 20 times higher then that of supermonitor. **From that it follows that the main part of the observed neutron flux in thunderstorm events consists of the low-energy particles."**

New evidence for low energy neutron fluxes in lightning - VIII

Data consistent with WLS many-body collective magnetic mechanism

"Strong flux of low-energy neutrons produced by thunderstorms," A. Gurevich *et al.*, *Physical Review Letters* **108** pp. 125001 - 4 (March 2012) http://prl.aps.org/abstract/PRL/v108/i12/e125001

Discussion (continued - 2): "It should be stressed, that such relationship between the signal in the low and high ranges of neutron energy, when just the low-energy neutron flux resolutely prevails above the high-energy one, is quite unusual and directly opposite to determined domination of the high-energy neutron signal observed generally in interaction of the cosmic ray hadronic component."

"The neutron background intensity at the internal TND is higher than at the external one. To the contrary according to the Table I the neutron count rate enhancements during thunderstorms are stronger at the external TND than at the internal TND and even more than at the underfloor TND. It means that neutrons observed during the enhancement event are generated in the air and in the upper layer of the ground, what may indicate the possibility for neutrons to be born in photonuclear process by γ-rays generated in atmospheric discharge."

"Taking into account the minute neutron counting rates registered in thunderstorm period and the effective sensitive surface of the TNDs, one can state, that the additional neutron fluxes during thunderstorm reach the extremely high values of the order of (3 – 5) x 10^{-2} neutrons cm^{2} s^{-1}. **This flux value constitutes a serious difficulty for the photonuclear model of neutron generation in thunderstorm.** Simulations of low-energy neutron generation both in air and in the ground show that an extraordinary large intensity of γ-radiation in the energy range 10 - 30 MeV, of the order of 10 - 30 quanta cm^{-2} s^{-1} is needed to obtain the observed neutron flux. Quite the same high flux value was observed in thunderclouds in balloon experiment at the height 5 km and in the highest point of the ground experiment at the height 4 km. At lower heights the flux was an order of magnitude less. But in all these observations the γ-radiation intensity was observed at moderate energies 50 - 200 keV. **As for the high energies 10 - 30 MeV, the only work where the flux of the γ-ray emission during thunderstorms was measured from the ground is [8]. The obtained γ-ray emission flux was about 0.04 quanta cm^{-2} s^{-1}, 3 orders of magnitude less than the needed value."**

High-energy processes: lightning laced w. dust/aerosols - I

Terrestrial gamma-ray flashes, x-rays, and neutrons: WLS mechanism at work?

Is nucleosynthesis occurring in high-current lightning emitting bursts of γ-rays, x-rays and neutrons?

Generalist Wikipedia article at URL = http://en.wikipedia.org/wiki/Terrestrial_gamma-ray_flash

- ✓ **See: "Electron-positron beams from terrestrial lightning observed with Fermi GBM," M. Briggs et al., *Geophysical Research Letters* 38, L02808 (2011) - free copy of preprint at URL =** http://sciences.blogs.liberation.fr/files/article-de-grl-sursaut-gamma-sur-terre.pdf

- ✓ **Also: "Origin of neutron flux increases observed in correlation with lightning," L. Babich and R. Roussel-Dupre´, *Journal of Geophysical Research* 112 D13303, doi:10.1029/2006JD008340 (2007)** http://crdlx5.yerphi.am/files/thunder/2007Babich0.pdf

- ✓ **Quoting abstract of Briggs et. al (2011): "Terrestrial Gamma-ray Flashes (TGFs) are brief pulses of energetic radiation observed in low-earth orbit. They are associated with thunderstorms and lightning and have been observed both as gamma-ray and electron flashes depending on the position of the spacecraft with respect to the source. While gamma-ray TGFs are detected as short pulses lasting less than 1 ms, most TGFs seen by the Fermi Gamma-ray Burst Monitor (GBM) with durations greater than 1 ms are, instead, the result of electrons traveling from the sources along geomagnetic field lines. We perform spectral analysis of the three brightest electron TGFs detected by GBM and discover strong 511 keV positron annihilation lines, demonstrating that these electron TGFs also contain substantial positron components. This shows that pair production occurs in conjunction with some terrestrial lightning and that most likely all TGFs are injecting electron-positron beams into the near Earth environment."**

High-energy processes: lightning laced w. dust/aerosols - II

Terrestrial gamma-ray flashes, x-rays, and neutrons: WLS mechanism at work?

- ✓ Quoting abstract of Babich and R-Dupre (2007): "The past decade of research into the phenomenon of lightning has seen an accumulation of evidence for the existence of penetrating radiation (*X*- and *γ*-rays) in direct association with many forms of discharges. As a result, our basic understanding of the mechanisms that produce lightning has shifted from the present paradigm based on conventional breakdown to a picture that incorporates the acceleration and avalanche of energetic particles. *Experiments conducted at high mountainous facilities in Gulmarg, India, have further confirmed the need for a paradigm shift.* These measurements have shown an enhancement in neutron flux in the atmosphere in correlation with lightning electromagnetic pulses. We demonstrate here that the prevailing neutron generation theory based on synthesis of deuterium nuclei in the lightning channel is not feasible. Instead, this phenomenon is most likely connected with photonuclear reactions produced as part of the recently elaborated theory of relativistic runaway breakdown."

- ✓ Duke University researcher comments on M. Griggs' January 10, 2011, presentation at the Winter Meeting of the American Astronomical Society: "The idea that any planet has thunderstorms that not only produce antimatter but then launch it into space seems like something straight out of science fiction," commented Steven Cummer of Duke University in Durham, North Carolina, who was not part of the study. "That our own planet does this, and has probably done it for hundreds of millions of years, and that we've only just learned it, is amazing to me."

- ✓ Lattice remark: too conservative; if the Fermi Gamma-ray Space Telescope's data and Griggs et al.'s interpretation are right, high-energy processes have been occurring in lightning for *billions* of years

High-energy processes: lightning laced w. dust/aerosols - III

Terrestrial gamma-ray flashes, x-rays, and neutrons: WLS mechanism at work?

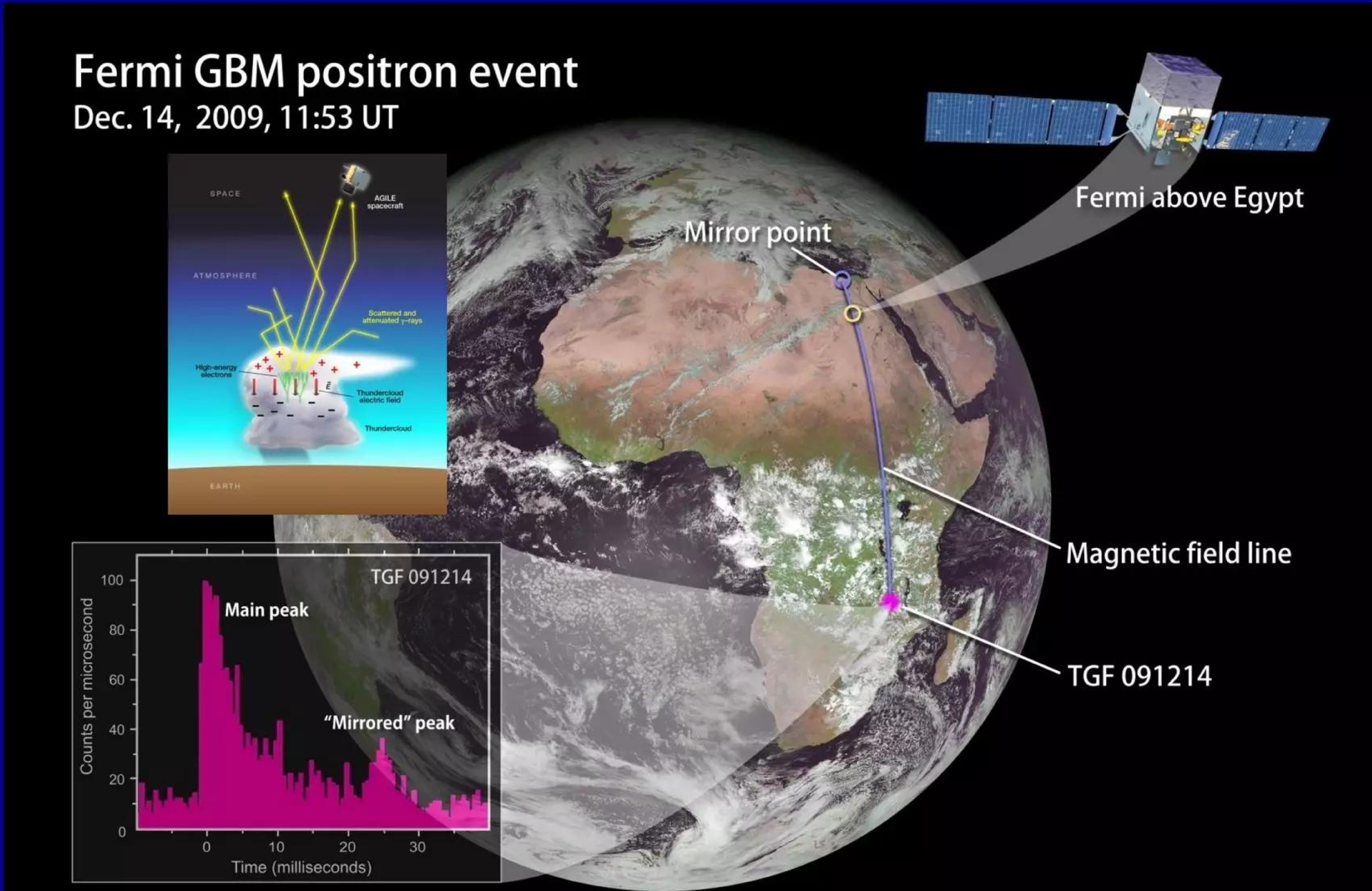
- ✓ **Lattice comments: on Earth, bolts of lightning can last for 30 - 50 microseconds and are well-known to involve electrical current pulses on the order of 30,000 to 100,000 Amperes (3 x 10^4 A to 1 x 10^5 A). Importantly, such values for peak current easily exceed a key threshold identified in our theoretical work, $I_o \approx 1.704509 \times 10^4$ Ampere (~17,000 A), that is required for the possibility of triggering weak interaction production of neutrons and/or creating energetic charged particles via $e^- + p^+ \rightarrow lepton + X$ reactions in lightning channel plasmas or $e^* + p^+ \rightarrow n + \nu_e$ reactions and subsequent neutron captures by atoms located on surfaces of 'dust' particles that are trapped within lightning channels during discharge**

- ✓ **Also, please recall from our arXiv and *Pramana* papers that (quoting), "In the vacuum, there is a mutual Coulomb repulsion between the electrons in the beam which compensates the mutual Amperian current attraction. In the exploding wire filament, on the other hand, the repulsive Coulomb part is screened by the background positive charge but *leaves intact the Amperian current attraction thereby allowing the possibility of nuclear reactions*."**

- ✓ **Thus, all other things being equal this implies that: within reasonable limits, the 'dustier' the plasma (dust particles assist by 'donating' emitted positive ions that help screen electron Coulomb repulsion) and the higher the electrical current pulse, the easier it becomes to increase a plasma's chemical potential to the point where nuclear reactions of the general forms shown above can be triggered**

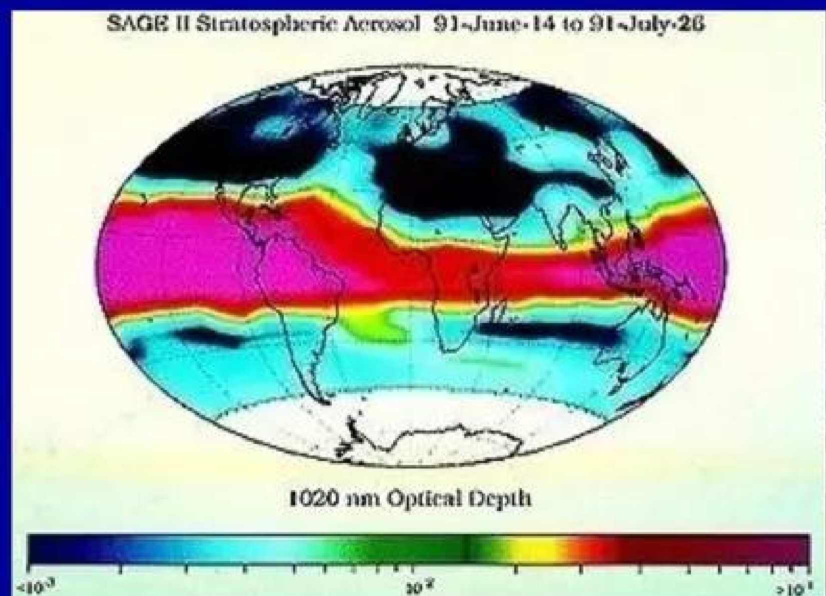
- ✓ **This line of reasoning would suggest that, on Earth and other planets where atmospheric lightning occurs, manifestations of high-energy electronic and nuclear processes in lightning discharges (x-rays, γ- rays, neutrons, 'hot' electrons, positrons, etc.) should be more commonly observed in regions where there are higher levels of dust/aerosol particles that could be trapped in lightning channels. We shall now examine some crude qualitative evidence which suggests that this might be true here on Earth**

High-energy processes: lightning laced w. dust/aerosols - IV

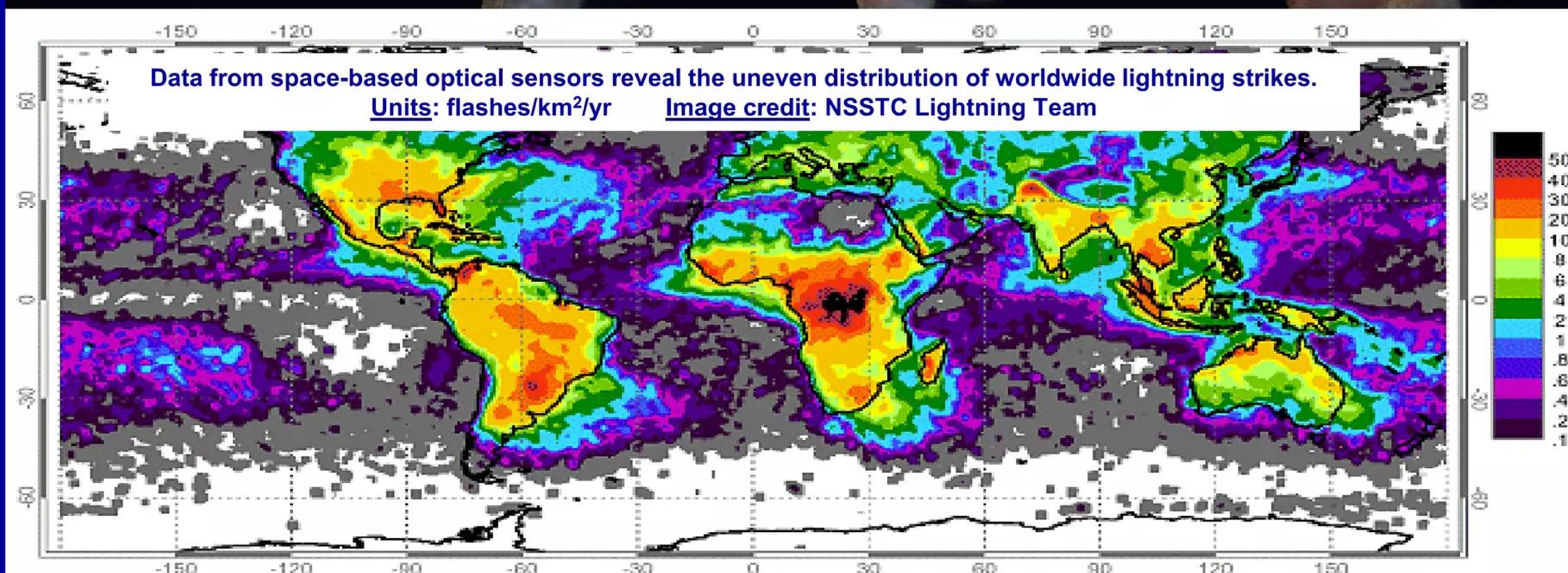


See source URL = http://www.nasa.gov/mission_pages/GLAST/news/fermi-thunderstorms.html
Related paper is at URL = http://sciences.blogs.liberation.fr/files/article-de-grl-sursaut-gamma-sur-terre.pdf

High-energy processes: lightning laced w. dust/aerosols - V

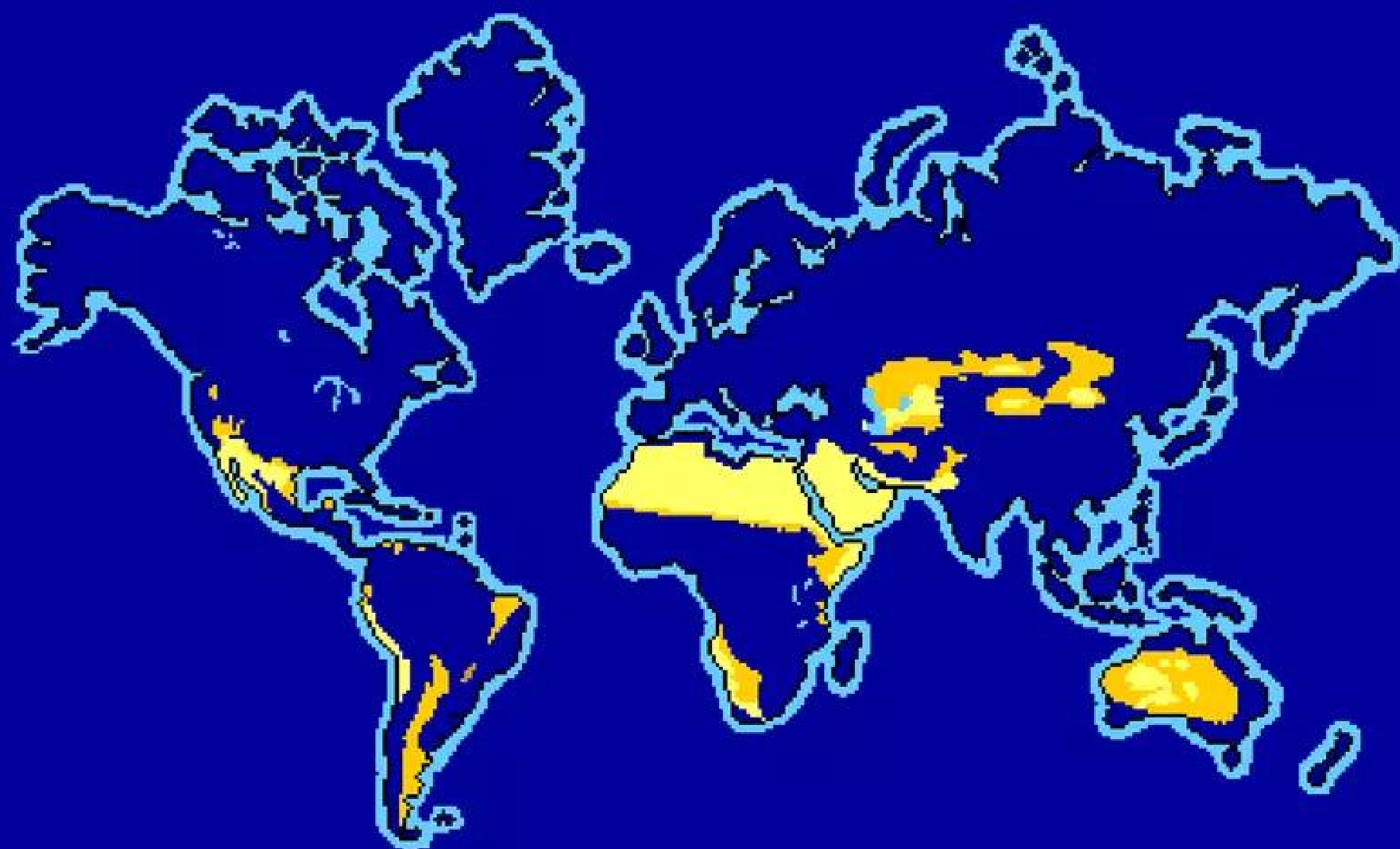


Shown above are aerosol concentrations over a period of six weeks, during summer 1991, as measured by SAGE-II. Note: these instruments flew on other satellites, including two in the NOAA series.

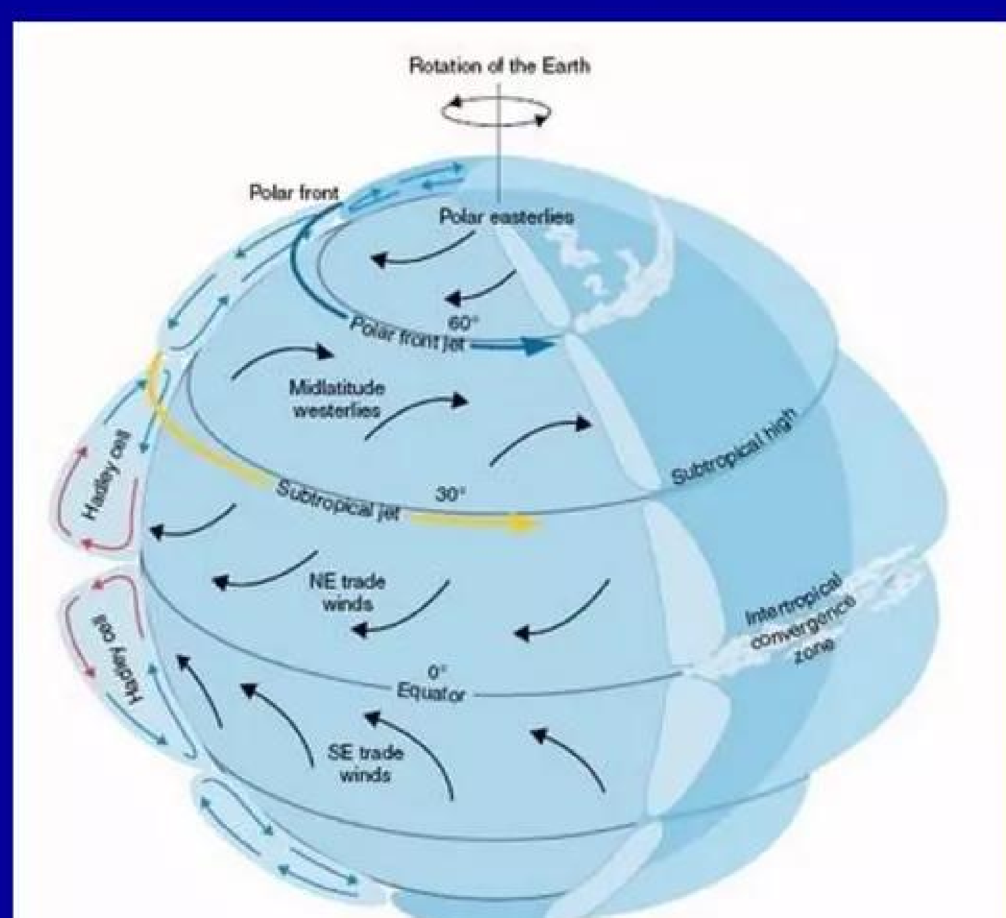


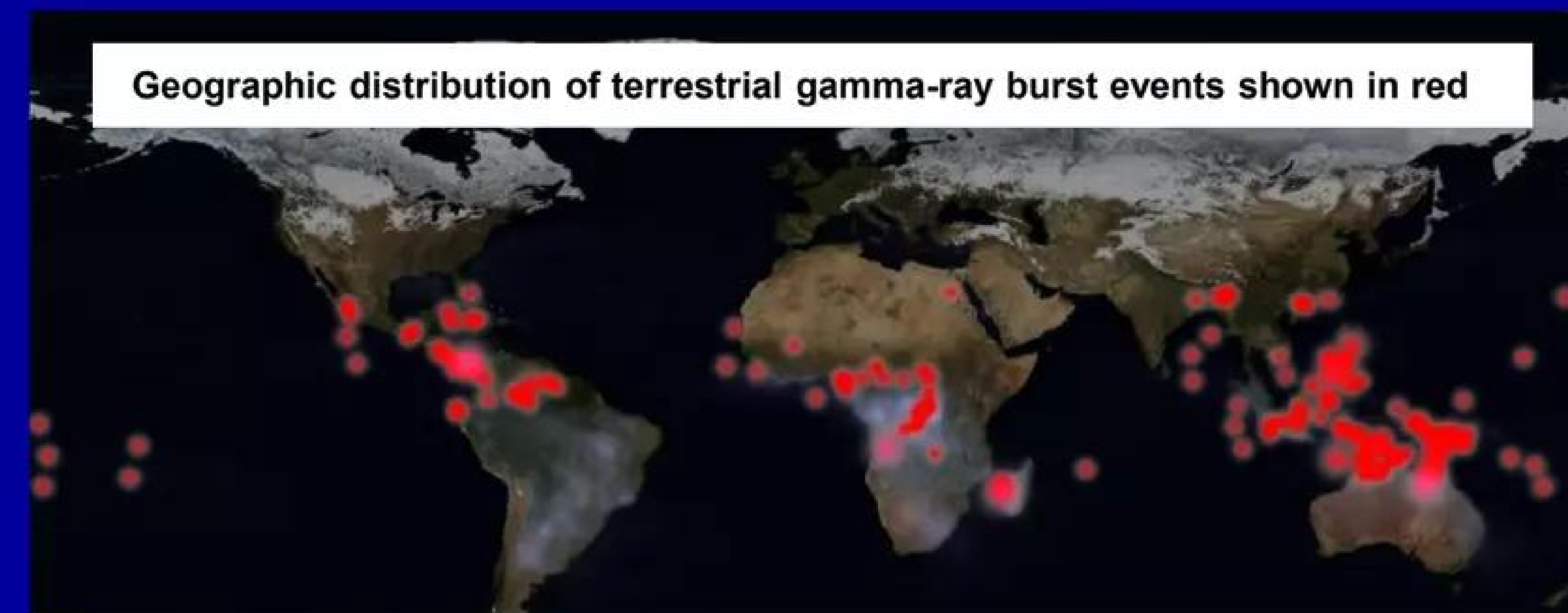
High-energy processes: lightning laced w. dust/aerosols - VI

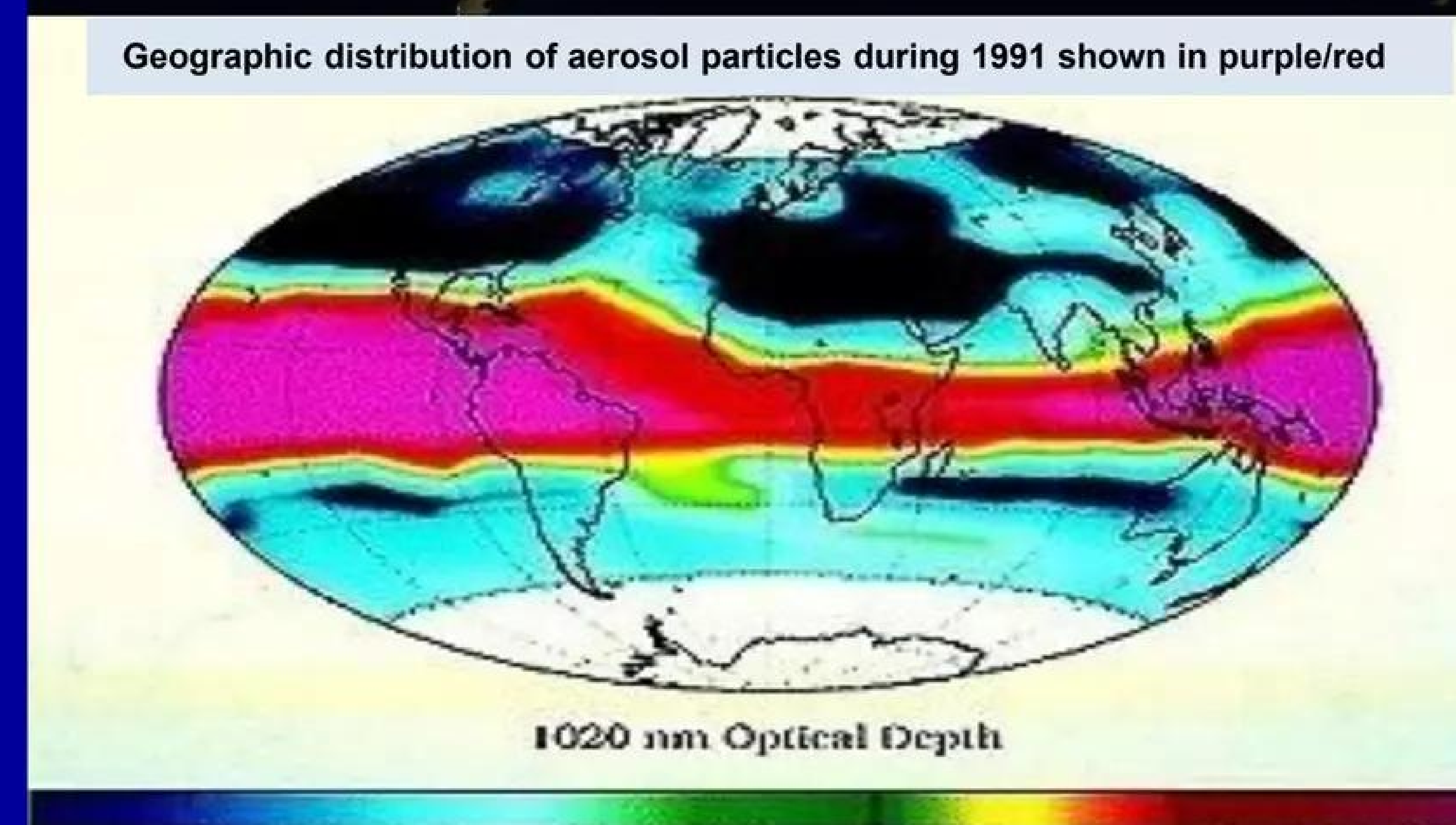
Earth's present deserts

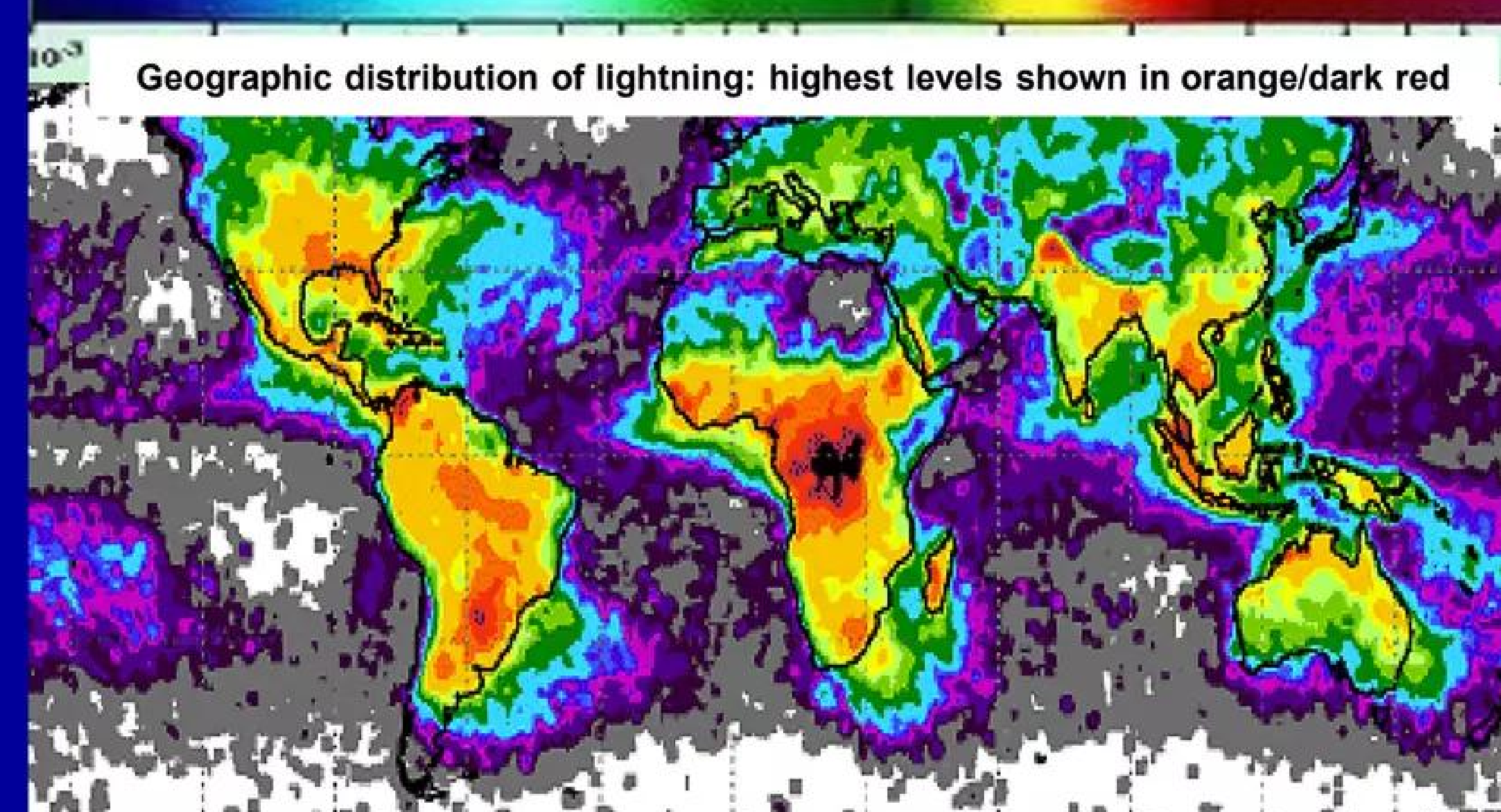


Earth's prevailing winds









High-energy processes: lightning laced w. dust/aerosols - VII

Terrestrial gamma-ray flashes, x-rays, and neutrons: WLS mechanism at work?

- ✓ Lattice speculative conjecture: TGFs were first discovered in 1994 by the BATSE instrument on NASA's then-new Compton Gamma-ray Observatory spacecraft; the newer RHESSI satellite has observed higher-energy gamma emissions (up to 20 MeV) than BATSE did

- ✓ Latest observations see only ~50 TGFs/day, larger value than previously thought but still a very tiny fraction of the estimated total world lightning strikes of 3 - 4 million/day; thus, TGFs appear to be a comparatively rare phenomenon on the Earth compared to 'ordinary' lightning discharges

- ✓ A naïve assumption would be that the global distribution of observed TGFs should closely mirror the global geographic distribution of lightning activity; as one can see from visual inspection of the previous charts, that notion is somewhat, but not rigorously true. For example, a region northwest of Australia is a major 'hot spot' for TGFs, yet that area does not seem to be characterized by unusually high levels of lightning activity --- ditto for Central America versus Brazil; look for yourselves

- ✓ So what else might help explain the distribution of TGFs? Well, deserts scoured by winds can put particles into the air; so can volcanic activity (aerosols as well as particulate dust). When one mentally superimposes the distributions of dust/aerosols on top of the distribution of lightning activity, distribution of TGFs then seems to make better sense; using a logical AND: lightning discharges + embedded dust/aerosols → TGFs

- ✓ A great deal of additional investigation and data collection would have to be performed to thoroughly evaluate this conjecture; that nontrivial task will be left to specialists if they have the interest and time to do so

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What can we now say about lightning with confidence?

Significant fluxes of neutrons can be produced in lightning bolt channels

Such neutrons will be captured on nearby atoms: this results in nucleosynthesis

Cores of stars, fission reactors, and supernovae are thus not required

- ✓ **Neutron fluxes are produced during lightning discharges in earth's atmosphere**; presumably this would also be true for lightning associated with dust in terrestrial volcanic eruptions as well as similar discharges occurring on other planetary bodies in our solar system
- ✓ **WLS weak interaction neutron production mechanism is the only theoretical approach that can readily explain all of the published experimental data;** Gurevich *et al.'s* new results rule-out previously popular photonuclear mechanism (nuclear fusion processes had been decisively ruled-out as a reasonable explanation some years earlier)
- ✓ Vast majority of neutrons produced in lightning discharges will likely be captured by nearby atoms before newly created free neutrons can decay (half-life of a free neutron is ~13 minutes); **therefore, neutron-catalyzed nucleosynthesis at low rates has likely been occurring continuously in earth's atmosphere for perhaps ~4.5 billion years**
- ✓ **Cores of stars, fission reactors, and supernovae not necessarily required for nucleosynthetic processes to occur; WLS $e + p$ mechanism enables star-like transmutation networks whose results are superimposed on products of earlier stellar processes**

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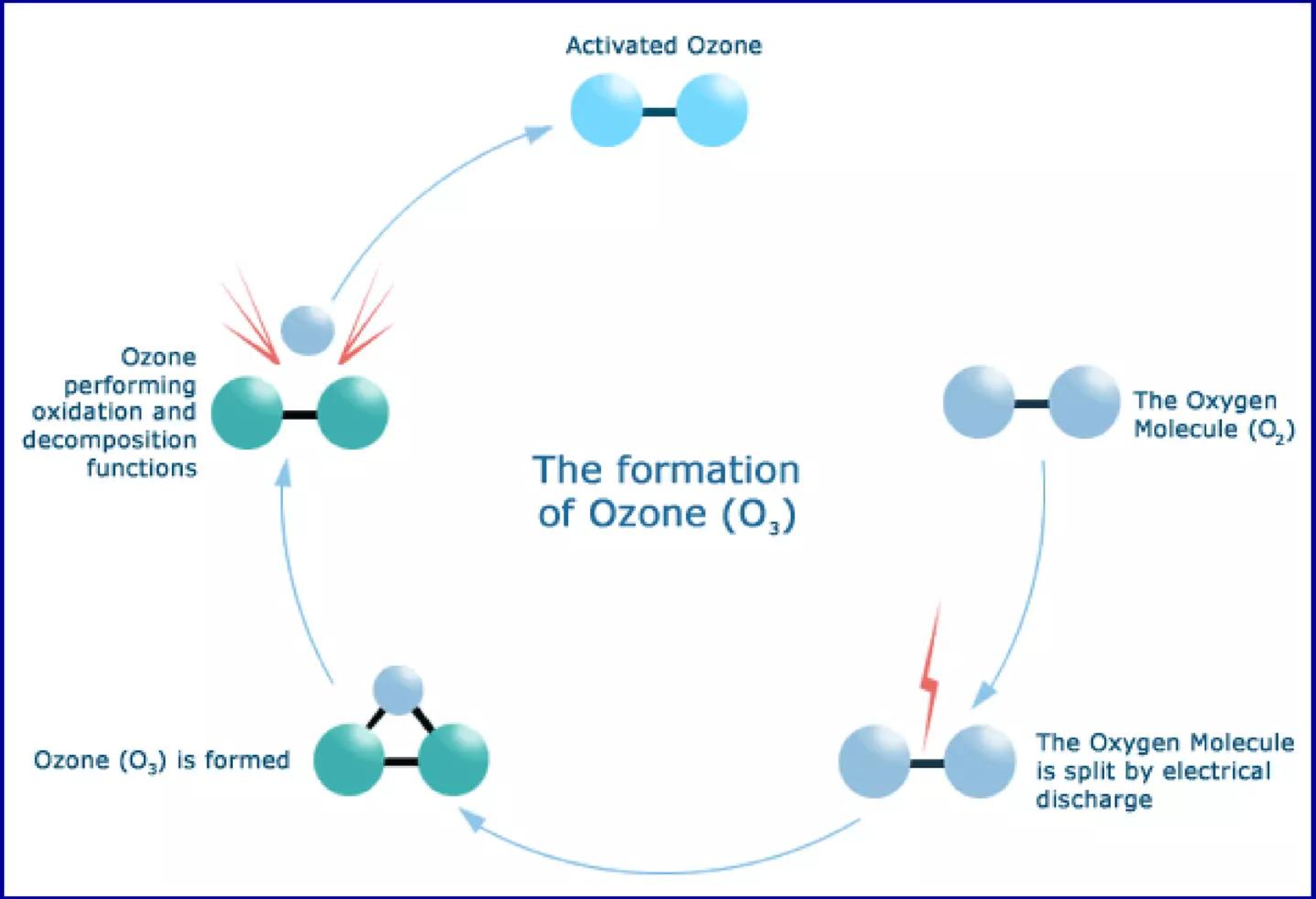
Lightning produces copious quantities of Ozone (O_3)

Many opportunities for lightning-produced neutrons to capture on Oxygen



Commercializing a next-generation source of CLENR energy

Lightning-produced neutrons can capture on O and N atoms

Oxygen natural abundance:

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

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

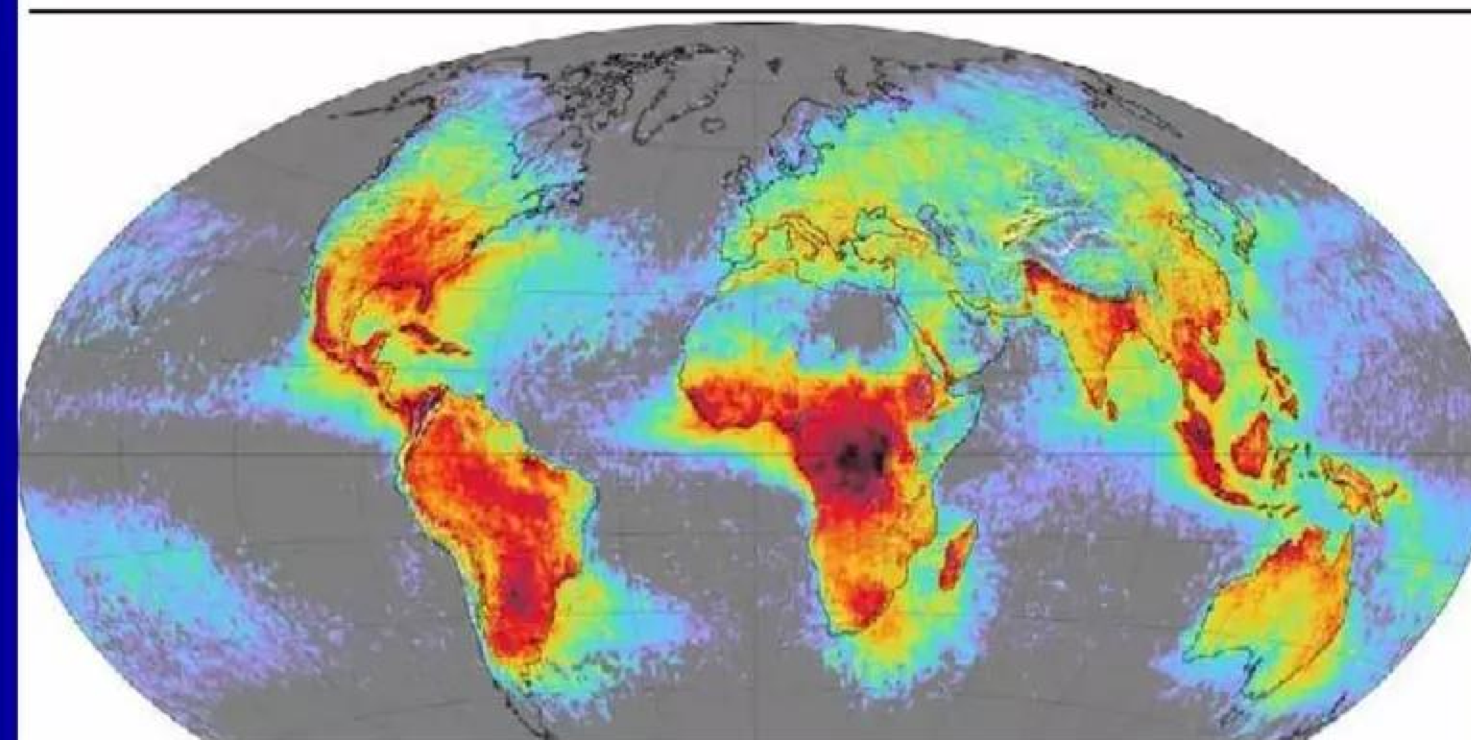
Thus, all other things being equal, repeated or protracted exposure of Oxygen atoms to ULM neutrons would tend to increase $\delta^{18}O$

Nitrogen and Oxygen are the most common gaseous constituents of the earth's atmosphere. That being the case, and excluding neutron captures on elements located in trapped dust particles, they both could readily capture neutrons produced in atmospheric lightning discharges.

N.B. - so-called "mass-independent" isotopic fractionation is well-known in earth's lightning-produced Ozone (O_3)

Table 1–2 Principal gases of dry air

Constituent	Percent by Volume	Concentration in Parts Per Million (PPM)
Nitrogen (N_2)	78.084	780,840.0
Oxygen (O_2)	20.946	209,460.0
Argon (Ar)	0.934	9,340.0
Carbon dioxide (CO_2)	0.036	360.0
Neon (Ne)	0.00182	18.2
Helium (He)	0.000524	5.24
Methane (CH_4)	0.00015	1.5
Krypton (Kr)	0.000114	1.14
Hydrogen (H_2)	0.00005	0.5



Q. *"How much ozone does one lightning strike produce?"* A. ~418 lbs
http://www.teamenterprise.ca/pages/OzoneProductionfromLightning.pdf

Fig. 9. From Schumann & Huntrieser, 2007 - Global distribution of annually averaged lightning flash frequency density derived from data of LIS between 1997 and 2002, and OTD between 1995 and 2000 (from NASA's Global Hydrology and Climate Center at Marshall Space Flight Center, 2006). The maximum and global mean flash density values are 80 km−2 a−1 and 2.7±0.3 km−2 a−1, respectively

Nitrogen natural abundance:

^{14}N = 99.632%; ^{15}N = 0.368%

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

Thus, all other things being equal, such nuclear reactions would likely tend to create increases in $\delta^{15}N$

Most abundant Oxygen isoptope, ^{16}O has thermal neutron capture cross-section of 0.19 millibarns (mb); ^{14}N has thermal neutron capture cross-section of 0.080 barns, so both will capture free neutrons produced via WLS mechanism in lightning bolts.

N.B. - NASA Genesis Mission O and N isotopic data (discussed later) isn't explained by chemical fractionation

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WLS mechanism & lightning with trapped dust and aerosols

Intense lightning activity observed in atmospheres of gas giant planets

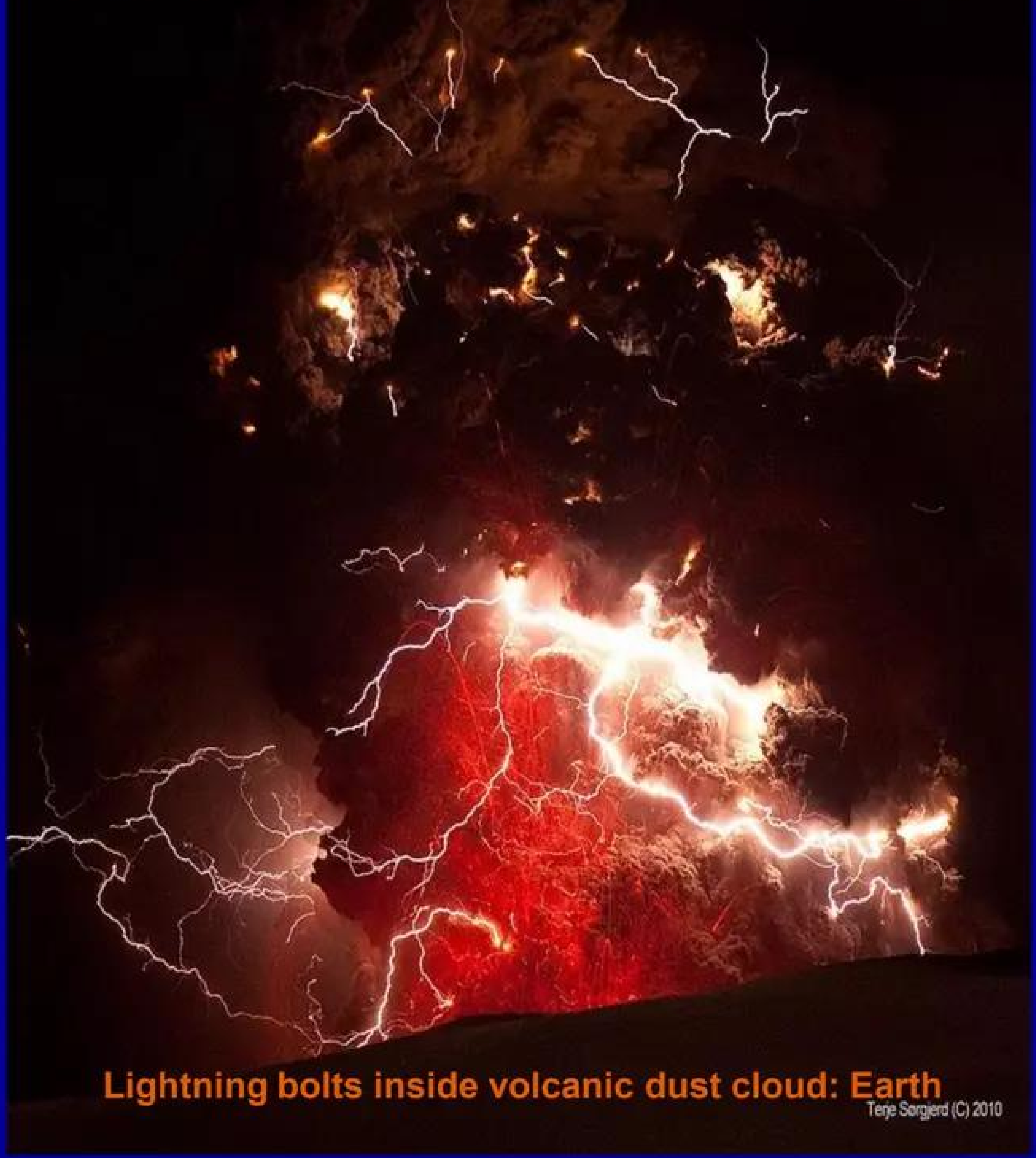
Could lightning-driven nucleosynthesis provide an additional heat source on other planets?
Could such processes also potentially contribute to various types of isotopic anomalies?

- ✓ **Lattice speculative conjecture: thanks to interplanetary probes, it is now well known that substantial amounts of violent lighting occurs in the atmospheres of Jupiter, Saturn, Neptune, and to a much lesser degree, Uranus. It is also well-known that their atmospheres are all rich in Hydrogen in various forms and contain variable quantities of dust --- thus, they possess all the necessary ingredients for the WLS nucleosynthetic mechanism. It is also well known that Jupiter radiates ~2.7 times as much energy as it receives from the Sun; Saturn ~3.0x; Neptune ~2.7x; and Uranus ~1.0x. *We wonder whether WLS nucleosynthetic processes could be contributing to such energy production?***

- ✓ **Up until now, most of us (the author included) have thought in terms of there being a sharp line of demarcation between 'stars' and 'planets,' stars being where fusion-driven nucleosynthesis took place and planets where almost entirely chemical processes occurred. Viewed through that long-standing conceptual paradigm, Jupiter and like gas-giant planets were regarded by many as "*failed stars*." Well, that view may have to be revised. *Perhaps there exists a continuum of energy-producing objects between radiologically dead rocky planets and super-hot fusion stars* --- the middle-ground being occupied by nucleosynthetically dynamic objects with increasing amounts of LENRs taking place in them. *Maybe Jupiter, Saturn, and "brown dwarfs" didn't fail?***

- ✓ **Again, a great deal of additional investigation and data collection would have to be conducted to thoroughly evaluate this additional conjecture based on our theoretical work. That admittedly daunting, definitely nontrivial task will be left to specialists if they have the time, resources, and interest to do so**

See: *"Lightning on the giant planets with focus on Saturn"*
G. Fischer *et al.* [24 PowerPoint slides]
COST P18 Conference – Vienna (2009)
http://www.costp18-lightning.org/Publications/Symposium2009/Release/S1/06_Fischer.pdf



Lightning bolts inside volcanic dust cloud: Earth

WLS mechanism & lightning processes in solar nebula - I

Triboelectric charging mechanism enables nebular lightning: Desch & Cuzzi

Some now believe dust processing by lightning important phenomenon in early days of solar system

"The generation of lightning in the solar nebula"
S. Desch and J. Cuzzi
Icarus **143** pp. 87 - 105 (2000)
http://dusty.la.asu.edu/~desch/publications/2000/Desch+Cuzzi2000.pdf

"**The process that melted and formed the chondrules, millimeter sized glassy beads within meteorites, has not been conclusively identified.** Origin by lightning in the solar nebula is consistent with many features of chondrules, but no viable model of lightning has yet been advanced. We present a model demonstrating how lightning could be generated in the solar nebula which differs from previous models in two important aspects. First, we identify a new, powerful charging mechanism that is based on the differences in contact potentials between particles of different composition, a form of **triboelectric charging.** In the presence of fine silicate grains and fine metal grains, large silicate particles (the chondrules) can acquire charges > $+10^5\ e$. Second, we assume that the chondrule precursor particles are selectively concentrated in clumps >100 km in size by the *turbulent concentration mechanism* described by J. N. Cuzzi *et al.* (1996, in *Chondrules and the Protoplanetary Disk,* pp. 35 - 43, Cambridge Univ. Press). **The concentration of these highly charged particles into clumps, in a background of negatively charged metal grains, is what generates the strong electric fields. We calculate that electric fields large enough to trigger breakdown easily could have existed over regions large enough (~100 km) to generate very large discharges of electrical energy (~10^{16} erg), assuming a lightning bolt width <10 electron mean-free paths. The discharges would have been sufficiently energetic to have formed the chondrules."**

"**The key features of these two new processes - very large charges on particles and very high concentrations of those particles – are at first surprising in their magnitude**. In astrophysical circles, grains in dense environments are usually assumed to be poorly charged. Large charges on particles are not uncommon in geological settings, though ... Lightning generation would seem to be more efficient closer to the Sun. If $\alpha = 10^{-4}$, lightning easily could be generated out to 3 AU; if $\alpha = 10^{-2}$, lightning could take place only within 1 AU. The asteroid belt, the site of the chondrules we observe today, may not be the favored environment for chondrule formation. **Chondrule formation closer in (e.g., at 1 AU) might be much more efficient, as lightning bolts would be more frequent and energetic, and could be generated for a greater fraction of the nebula lifetime, due to the increased density there."**

"Lightning processing of dust in the solar nebula"
J. Nuth et al., LPI Contribution No. 1639 pp.9019
Workshop on: Formation of the First Solids in the Solar System (Kauai, Hawaii Nov. 7 - 9, 2011)
Sponsored by: Lunar and Planetary Institute and the Universities Space Research Association (USRA)
http://www.lpi.usra.edu/meetings/solids2011/pdf/9019.pdf

"Lightning as the Processing Agent: **Based on experiments done at GSFC that produced non-mass-dependently fractionated solid oxides from plasma, we have previously suggested that dust processed via nebular lightning could explain the observed oxygen isotopic distribution in the solar system.** Necessary conditions for nebular lightning have been previously discussed. **We will present preliminary work suggesting that lightning is a major component of protostellar nebulae. We will also present preliminary results of the time dependent evolution of oxygen isotopes in nebular dust"**

WLS mechanism & lightning processes in solar nebula - II

Established that neutrons are produced and captured in lightning discharges

Neutron captures alter isotopes, create different elements via decays = non-stellar nucleosynthesis

Summary so far:

- ✓ **Significant measurable fluxes of low energy neutrons are commonly produced in ordinary lightning discharges**
- ✓ WLS $e + p$ weak interaction mechanism best theoretical explanation for observed neutron production in lightning
- ✓ Vast majority of neutrons produced in lightning will be captured by various atoms before decaying back into protons & electrons
- ✓ Atoms that capture neutrons will be transmuted into heavier stable or unstable isotopes; many unstable nucleosynthetic products will subsequently beta-decay and thus change to heavier elements in the same row on the periodic table
- ✓ Non-stellar LENR nucleosynthesis on planets is therefore real
- ✓ Has probably occurred on earth from start ~4.5 billion years ago
- ✓ If lightning discharge processes were important phenomena in early solar system prior to planet formation, some level of non-stellar LENR nucleosynthetic activity must have occurred on solar system materials; that would have created isotopic and elemental “fingerprints’ measurable with mass spectroscopy
- ✓ **Paradigm shift**: perhaps some subset of isotopic data now being interpreted as mass-dependent/-independent chemical fractionation are really result of LENR transmutation processes?

“Gamma-ray bursts and other sources of giant lightning discharges in protoplanetary systems”
B. McBreen *et al.*
Astronomy & Astrophysics 429 pp. L41 – L45 (2005)
http://cdsweb.cern.ch/record/819653/files/0502010.pdf

Abstract: “**Lightning in the solar nebula is considered to be one of the probable sources for producing the chondrules that are found in meteorites**. Gamma-ray bursts (GRBs) provide a large flux of γ-rays that Compton scatter and create a charge separation in the gas because the electrons are displaced from the positive ions. The electric field easily exceeds the breakdown value of ≈ 1 V m^{-1} over distances of order 0.1 AU. **The energy in a giant lightning discharge exceeds a terrestrial lightning flash by a factor of ∼10^{12}. The predicted post-burst emission of γ-rays from accretion into the newly formed black hole or spindown of the magnetar is sufficiently intense to cause a lightning storm in the nebula that lasts for days and is more probable than the GRB because the radiation is beamed into a larger solid angle.** The giant outbursts from nearby soft gamma-ray repeater sources (SGRs) are also capable of causing giant lightning discharges. The total amount of chondrules produced is in reasonable agreement with the observations of meteorites. Furthermore in the case of GRBs most chondrules were produced in a few major melting events by nearby GRBs and lightning occurred at effectively the same time over the whole nebula, and provide accurate time markers to the formation of chondrules and evolution of the solar nebula. This model provides a reasonable explanation for the delay between the formation of calcium aluminum inclusions (CAIs) and chondrules.”

New isotopic measurements: Genesis Discovery Mission - I

NASA collected pristine solar wind samples; returned to Earth for analysis

Pattern of isotopes found in pristine solar wind upsets present ideas about solar system abundances

- ✓ **See**: "Solar composition from the Genesis Discovery Mission," D. Burnett and Genesis Science Team, *PNAS Early Edition* published ahead of print doi:10.1073/pnas.1014877108 (May 2011) Free copy at URL = http://www.pnas.org/content/early/2011/05/05/1014877108.full.pdf
- ✓ **Overview**: "Launched in 2001, Genesis placed a spacecraft at the easily reached L1 Lagrangian point, approximately 1% of the distance to the Sun, but away from perturbing influences of the terrestrial magnetic field. After collection, solar wind samples were returned to Earth in 2004." This paper provides a brief overview of some of the mission's important analytical results regarding isotope measurements
- ✓ **Quoting**: "The link between solar and planetary matter is that they have a common origin in the original cloud of gas and dust from which the solar system formed 4.57 x 10^9 years ago. Our gas-dust cloud is the first step in what cosmochemists regard, at least implicitly, as a 'Standard Model' for the origin of planetary materials. The formation of the Sun by gravitational collapse of the cloud occurs by the flow of material through an equatorial disk, the 'solar nebula,' onto the Sun, a process now directly observable in star-forming regions. The Standard Model regards elemental (the relative amounts of different elements) and isotopic (the relative amounts of the isotopes of individual elements) compositions of the solar nebula as homogeneous, at least on large scales relative to the size of individual dust grains. The planetary objects (planets, moons, asteroids, etc.) of the solar system are notable for their amazing degree of diversity yet they appear to have formed from a homogenous starting point. Most of the material in the solar nebula flowed to the Sun, thus in the solar surface layers, isolated from nuclear transformations in the solar core, the original average nebular composition is preserved for the vast majority of elements and isotopes. The Standard Model appears to be sufficiently accurate to serve as a starting point; it obviously leaves a lot to be desired in terms of specificity, and most interestingly, *it is clearly wrong in terms of the variations in the isotopic composition of some elements*. For example, at the level of a few percent or less, there are variations in the isotopic composition of O among inner solar system materials available for laboratory study."

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New isotopic measurements: Genesis Discovery Mission - II

NASA collected pristine solar wind samples; returned to Earth for analysis

Pattern of isotopes in solar wind upsets widely accepted ideas about solar system abundances

- ✓ **Quoting: "Oxygen isotope analyses - Fig. 3 shows schematically the variations in O isotopic compositions among inner solar system materials (8). The Genesis solar wind composition, measured with the UCLA MegaSIMS (Fig. 1A), is very different from most inner solar system materials, but lies near the linear trend set by meteoritic Ca-Al-rich inclusions (CAI). Models of solar wind acceleration (9) predict that O isotopes in the solar wind will be richer in ^{16}O than the Sun, with the amount of correction shown by the dashed line in Fig. 3. It is possible that the amount of correction shown is too large, so within present errors, the solar composition could lie on the CAI line. Several well studied natural processes exist which fractionate isotopes relative to the assumed Standard Model values, but none of these explain the variations shown on Fig. 3. A specific model based on the effects of self-shielding of ultraviolet radiation from the early Sun (10) predicts that the solar O isotopic composition would be ^{16}O-rich, lying along the CAI trend. The details of how this process would affect all of the material in the inner solar system are not clear. Conceivably, UV radiation plays a role in the growth of grains from micron to kilometer size. The Genesis $^{18}O/^{16}O$ ratio is lower by 17% from the ratio derived from intensities of solar molecular CO lines (11). It appears unlikely that Sun-solar wind isotopic fractionation of this magnitude has occurred; the origin of the discrepancy is unknown."**

- ✓ **Quoting: "Nitrogen isotope analyses - The variations in $^{15}N/^{14}N$ among solar system materials are much larger than for O and cannot be explained by well studied mechanisms of isotope fractionation. Although one analysis has given a higher ratio for as-yet-unknown reasons (12), Genesis data overall (13–17) show that the Sun is like Jupiter and very distinct from any known inner solar system material (Fig. 4). In this case four independent replicate analyses using different instruments was able clearly to recognize an anomalous result, illustrating the major advantage of sample return missions (Advantage iii above). No good models exist to explain the large solar system N isotopic variations."**

Commercializing a next-generation source of CLENR energy

New isotopic measurements: Genesis Discovery Mission - III

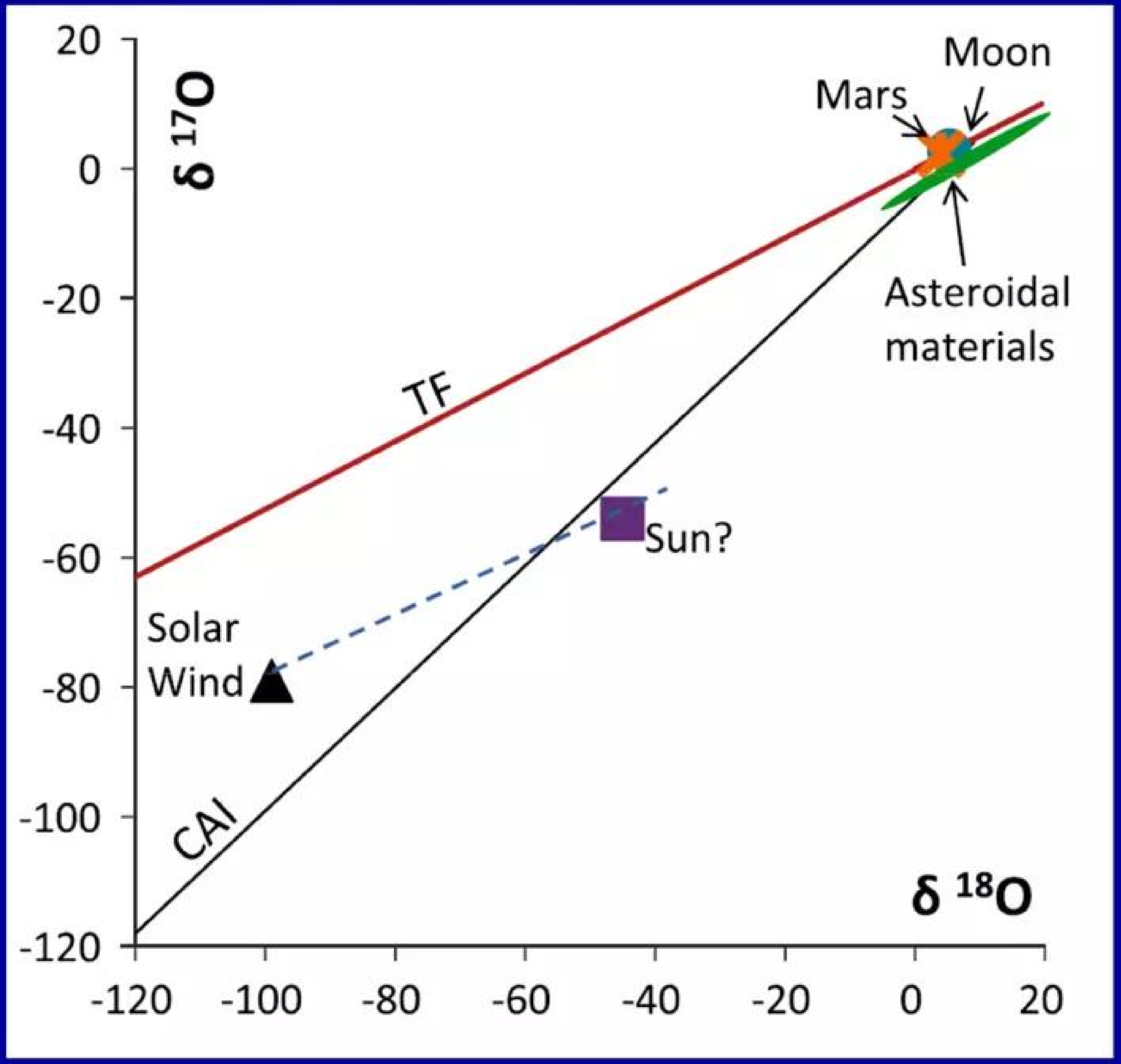
NASA collected pristine solar wind samples; returned to Earth for analysis

Pattern of isotopes in solar wind upsets widely accepted ideas about solar system abundances

Quoting comment made in May 2011 PNAS paper: "Several well studied natural processes exist which fractionate isotopes relative to the assumed Standard Model values, but none of these explain the variations shown on Fig. 3."

Quoting: "Fig. 3. A mass spectrometer measures separately the ion currents for the different isotopes of an element. Oxygen has three isotopes, allowing two isotopic abundance ratios to be calculated. Intersample variations are calculated as the fractional deviation *δ* of the measured $^{18}O/^{16}O$ or $^{17}O/^{16}O$ from terrestrial ocean water (‰ units are permil, parts in 1,000). Terrestrial geochemical processes produce a wide range in O [Oxygen] isotope fractionations, but these variations lie almost entirely on the line labeled TF (terrestrial fractionation). The Genesis solar wind composition (8) is very different from the major inner solar system objects (Earth, Moon, Mars) and most asteroidal (meteoritic) materials, but lies close to the trend set by unique high temperature Ca-Al-rich inclusions (CAI). Theoretically, solar wind acceleration fractionates isotopes by the amount shown by the line between the solar wind and the Sun? point (9)."

Oxygen Isotopes Figure 3. Burnett *et al., PNAS* (2011)



This is fascinating isotopic data

New isotopic measurements: Genesis Discovery Mission - IV

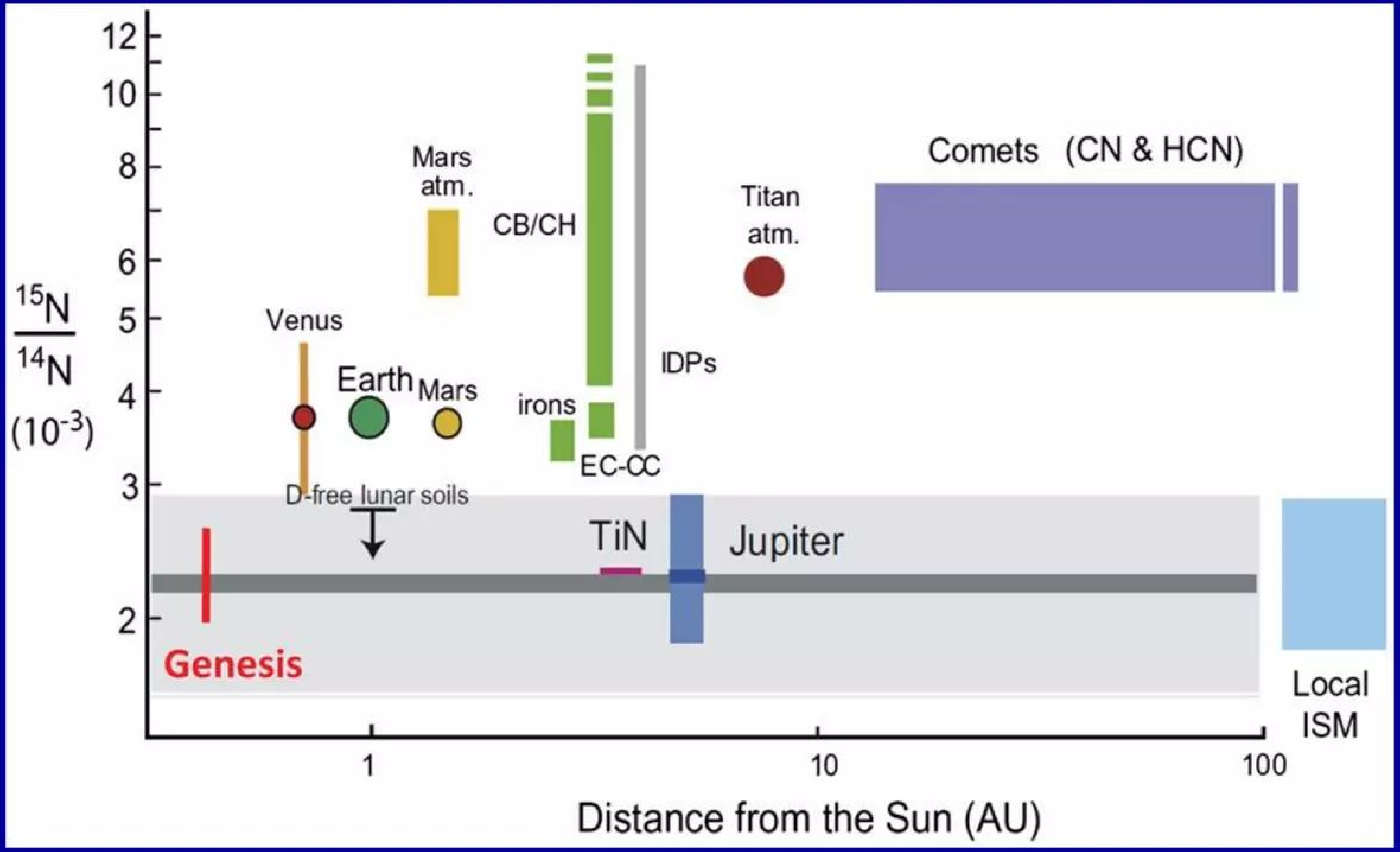
NASA collected pristine solar wind samples; returned to Earth for analysis

Pattern of isotopes in solar wind upsets widely accepted ideas about solar system abundances

Quoting comment made in May 2011 PNAS paper: "The variations in $^{15}N/^{14}N$ among solar system materials are much larger than for O and cannot be explained by well studied mechanisms of isotope fractionation."

Quoting: "Fig. 4. N isotopic compositions in solar system objects, [modified from Marty et al., (13)] vary widely, showing no simple heliocentric distance trend. Genesis data (13–16) show that the Sun is like Jupiter, whereas all inner solar system samples show much larger amounts of ^{15}N. The TiN analysis refers to a mineral from an unusual meteorite (17). The origins of these variations are unknown."

Nitrogen Isotopes Figure 3. Burnett et al., *PNAS* (2011)



New isotopic measurements: Genesis Discovery Mission - V

NASA collected pristine solar wind samples; returned to Earth for analysis

Pattern of isotopes in solar wind upsets widely accepted ideas about solar system abundances

- ✓ **Lattice comments: present astrophysical and geochemical thinking assume that fresh local nucleosynthesis of elements/isotopes (out beyond the photosphere of the solar system's protosun) had effectively ceased prior to condensation of materials comprising the primordial presolar nebula into a myriad of various-sized solid bodies, and prior to Earth becoming recognizable as a planet. In that view, only unstable isotopes with extremely long half-lives, e.g., the progenies of the U-series, Th-series, and ^{40}K, would be around long-enough to still be producing radiogenic heat inside planet-like bodies that comprise today's solar system**

- ✓ **In several SlideShare presentations, we have discussed some of the problems and inherent limitations of present-day chemical fractionation theories; see** http://www.slideshare.net/lewisglarsen/lattice-energy-llc-len-rs-in-catalytic-convertersjune-25-2010 **and** http://www.slideshare.net/lewisglarsen/bacteria-lenrsand-isotopic-shifts-in-uraniumlarsenlattice-energy-dec-7-2010-6177275 **(catalytic converters & biological LENRs)**

- ✓ **If one grants the possibility that nucleosynthesis can potentially occur (albeit at vastly lower aggregate rates than what may happen within hot stellar cores or supernovas) *outside the Sun's core*, elsewhere out in today's solar system, then many of the puzzling isotopic anomalies revealed in the Genesis Discovery Mission's data, that are inexplicable with present theories of chemical fractionation processes, might be better understood by utilizing WLS theory to help explain anomalous isotope production and related ratios**

- ✓ **Interesting footnote - in 2010 a new heretically titled article was added to Wikipedia: "Solar surface fusion" see URL =** http://en.wikipedia.org/wiki/Solar_surface_fusion **; while its focus is (quoting) "... fusion reactions occurring at or above the photosphere, most likely in the chromosphere," the fact that such an article exists suggests that the 'core only' paradigm is weakening and that more researchers are trying to come to grips with new observational data which strongly indicates that nucleosynthetic processes may not be strictly limited to cores of stars, natural and manmade fission reactors, and supernovae**

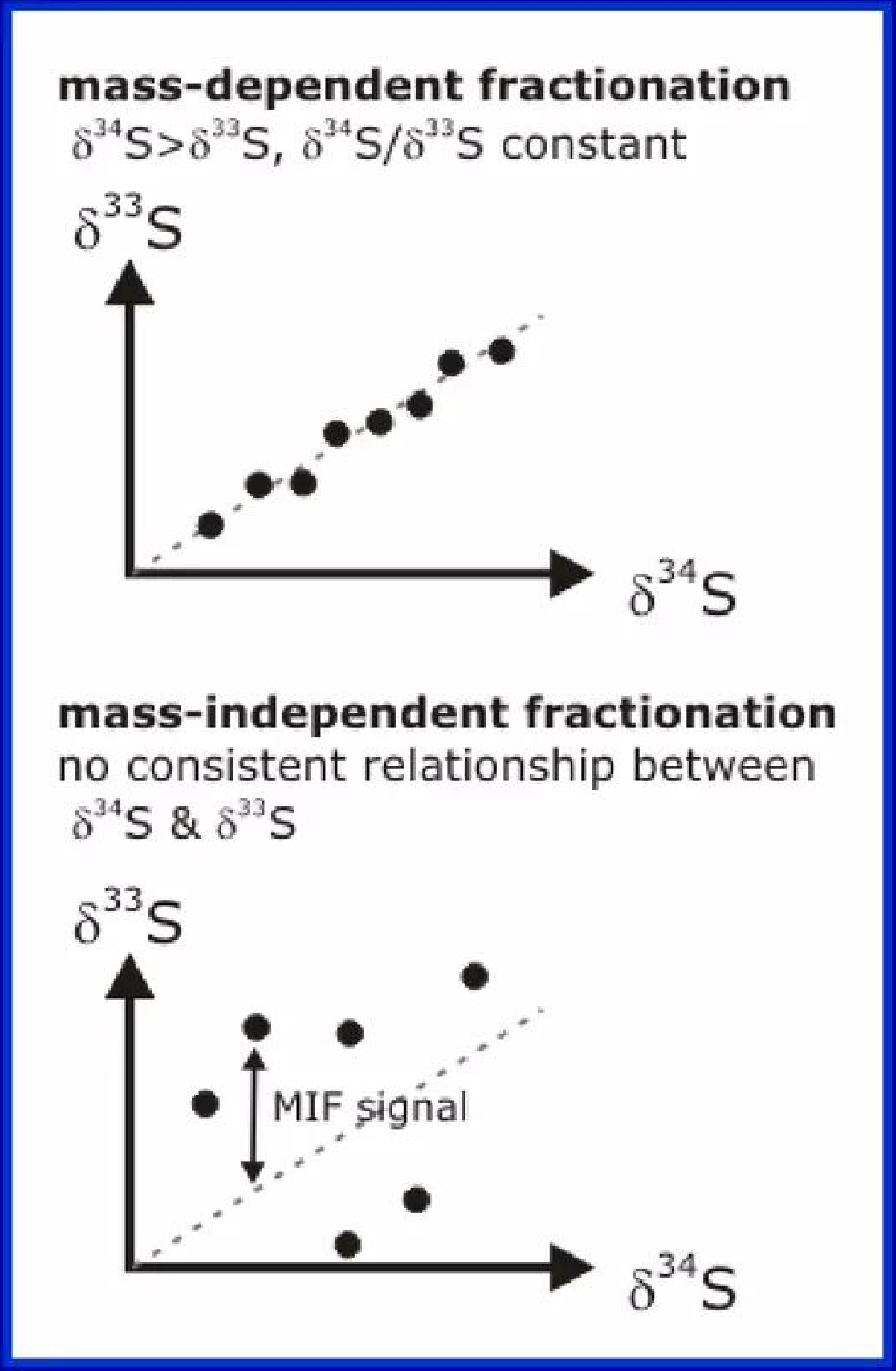
New possibility: chemical and nuclear processes

W-L theory and LENRs vs. chemical fractionation explanations - 1

- ✓ For ~ 60 years, a body of chemical fractionation theory has been developed and articulated to explain progressively increasing numbers of stable isotope anomalies observed in a vast array of mass spectroscopic data obtained from many different types of natural and experimental, abiological and biological, systems. Central ideas in "chemical fractionation" theory embody equilibrium and irreversible, mass-dependent and mass-independent, chemical and recently so-called "*nuclear field shift*" processes that are claimed to be able to separate isotopes, thus explaining reported isotopic anomalies

- ✓ Although not explicitly acknowledged by fractionation theorists, an intrinsic *fundamental* assumption underlying all of this theory and interpretation of data is that no nucleosynthetic processes are occurring anywhere in any of these systems, at any time, that are capable of altering isotope ratios and/or producing new mixtures of different elements over time; ergo, chemistry explains everything

- ✓ However, if WLS theory is correct, for some data the above fundamental assumption may be incorrect. For example, new Genesis Mission data for Oxygen and Nitrogen isotopes is inexplicable with chemical fractionation processes; however, it is readily understandable when instead viewed through lens of non-stellar LENR nucleosynthetic processes. As shown herein, atmospheric O_2 and N_2 can capture neutrons produced in lightning discharges, which alters isotopic ratios



New possibility: chemical and nuclear processes

W-L theory and LENRs vs. chemical fractionation explanations - 2

Let it be crystal clear exactly what we are and *are not* saying here:

- ✓ **We are not asserting that the existing chemical fractionation paradigm fails to adequately explain most reported isotope anomalies with respect to statistically significant deviations from natural abundances --- indeed, it may well effectively and accurately explain the vast majority of them**
- ✓ **We are saying that the presently available published literature does contain a significant subset comprising many cases in which the chemical fractionation paradigm must be pushed very hard (which includes use of various *ad hoc* constructs) to explain certain isotope anomalies, i.e. it is being overly stretched to be able to comfortably accommodate some data**
- ✓ **We are suggesting that in those particular instances, it may be fruitful for researchers to reexamine such data through the conceptual lens of the LENR paradigm to determine whether the new WLS approach can help lead to a deeper, easier understanding of reported experimental data. In some cases, it well may; in others it may not --- but we should look anyway**

Commercializing a next-generation source of CLENR energy

LENRs in condensed matter systems and dusty plasmas

Consequences of local breakdown in chemistry assumptions - 1

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

"Toto, I have the feeling we're not in Kansas anymore."

Dorothy in "The Wizard of Oz" (1939)

"There is nothing as deceptive as an obvious fact."

Sherlock Holmes, "The Boscombe Valley Mystery" (1891)

"These are very deep waters."

Sherlock Holmes, "The Adventure of the Speckled Band" (1892)

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

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

Commercializing a next-generation source of CLENR energy

LENRs in condensed matter systems and dusty plasmas

Consequences of local breakdown in chemistry assumptions - 2

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

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

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

LENRs in condensed matter systems and dusty plasmas

Consequences of local breakdown in chemistry assumptions - 3

Please recall the basic equation for fractionation:

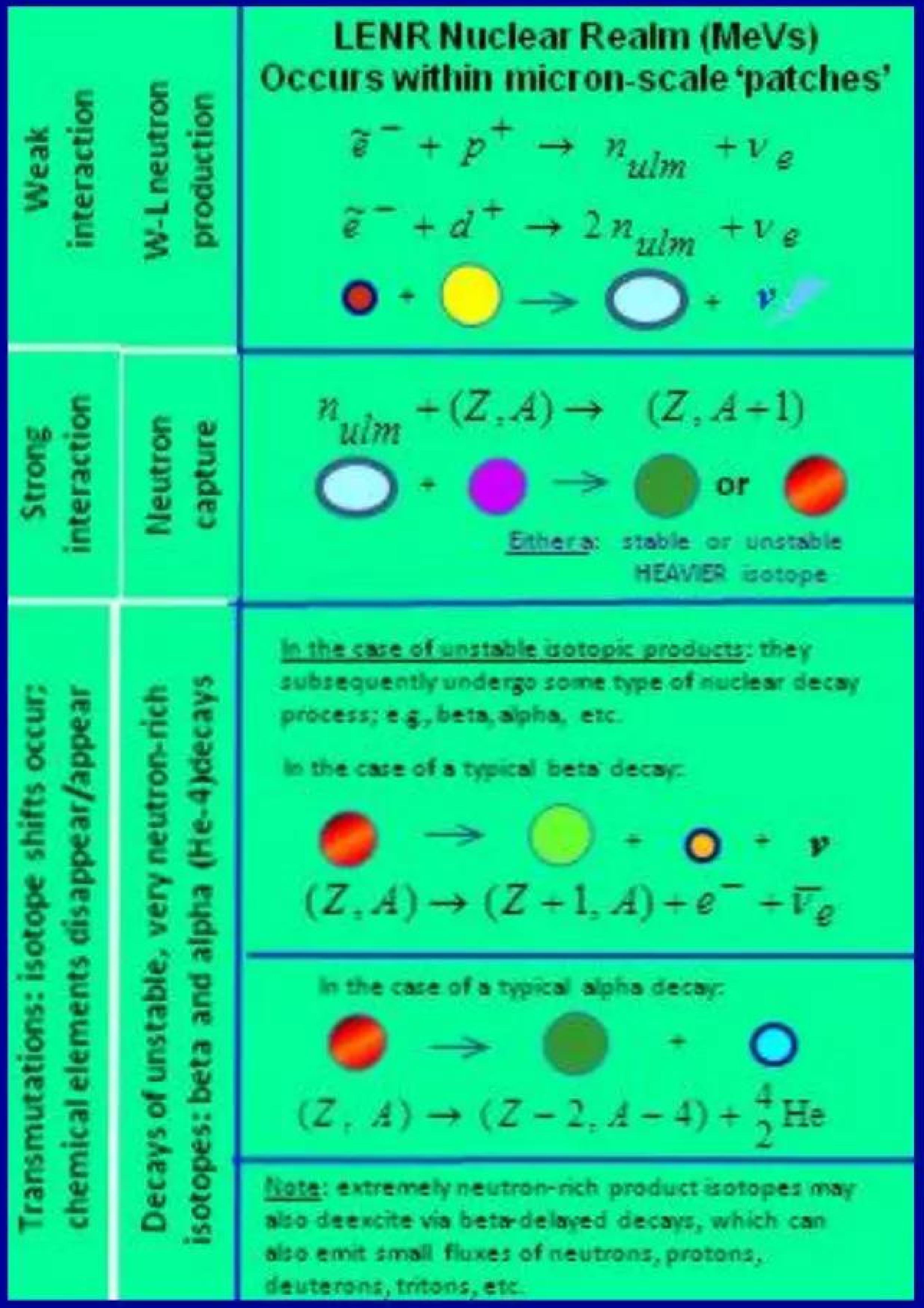
$$f = \frac{(heavy\,/\,light)\text{product}}{(heavy\,/\,light)\text{reactant}}$$

Now let us assume that in an idealized system:

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

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

<u>Key point</u>: products of LENR transmutation processes can readily mimic the effects of chemical fractionation



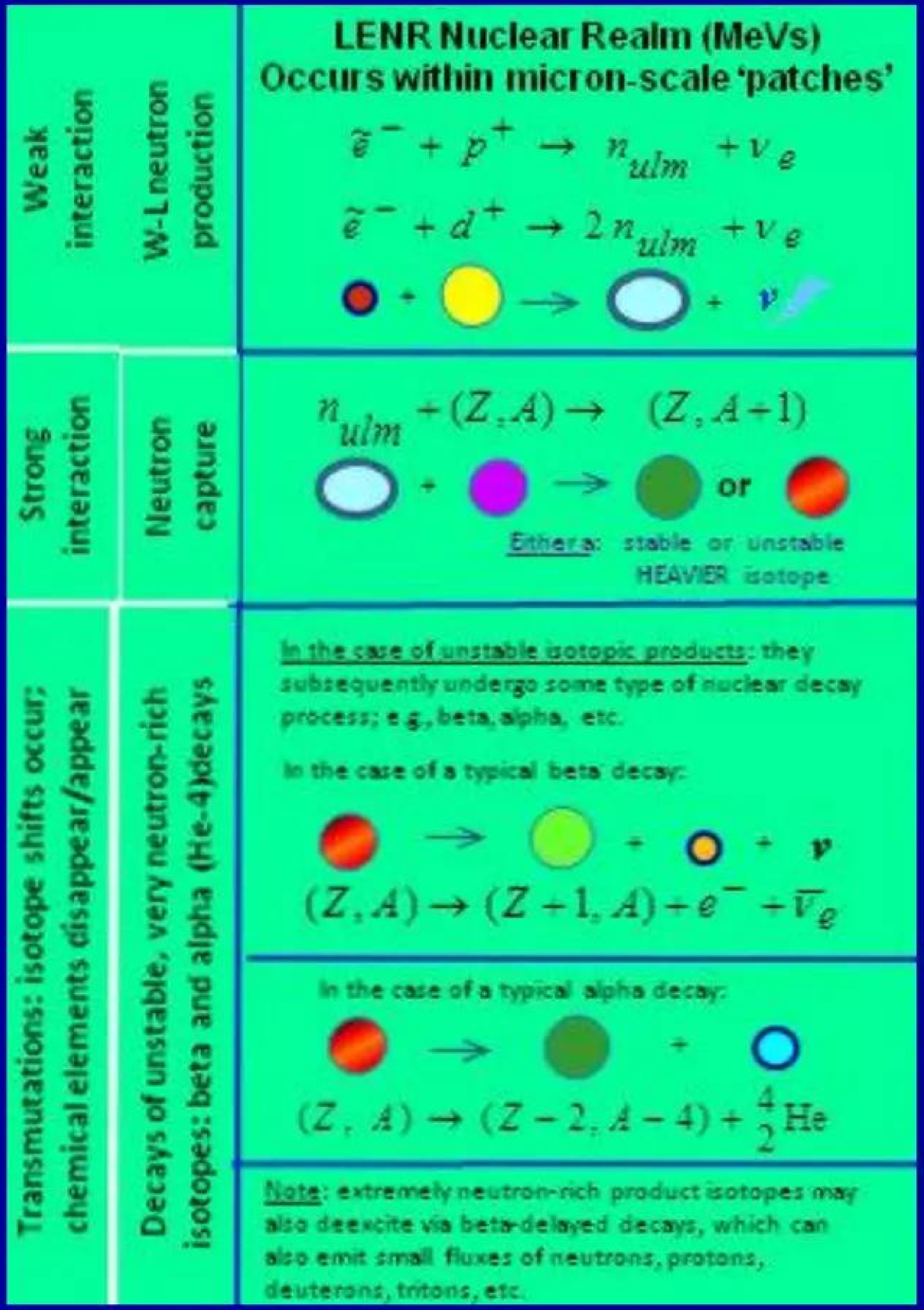
LENRs in condensed matter systems and dusty plasmas

Consequences of local breakdown in chemistry assumptions - 4

Now please recall the methodology for calculating δ:

$$\delta = \left(\frac{R_{sample} - R_{standard}}{R_{standard}}\right) x1000$$

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



Commercializing a next-generation source of CLENR energy

LENRs in condensed matter systems and dusty plasmas

Consequences of local breakdown in chemistry assumptions - 5

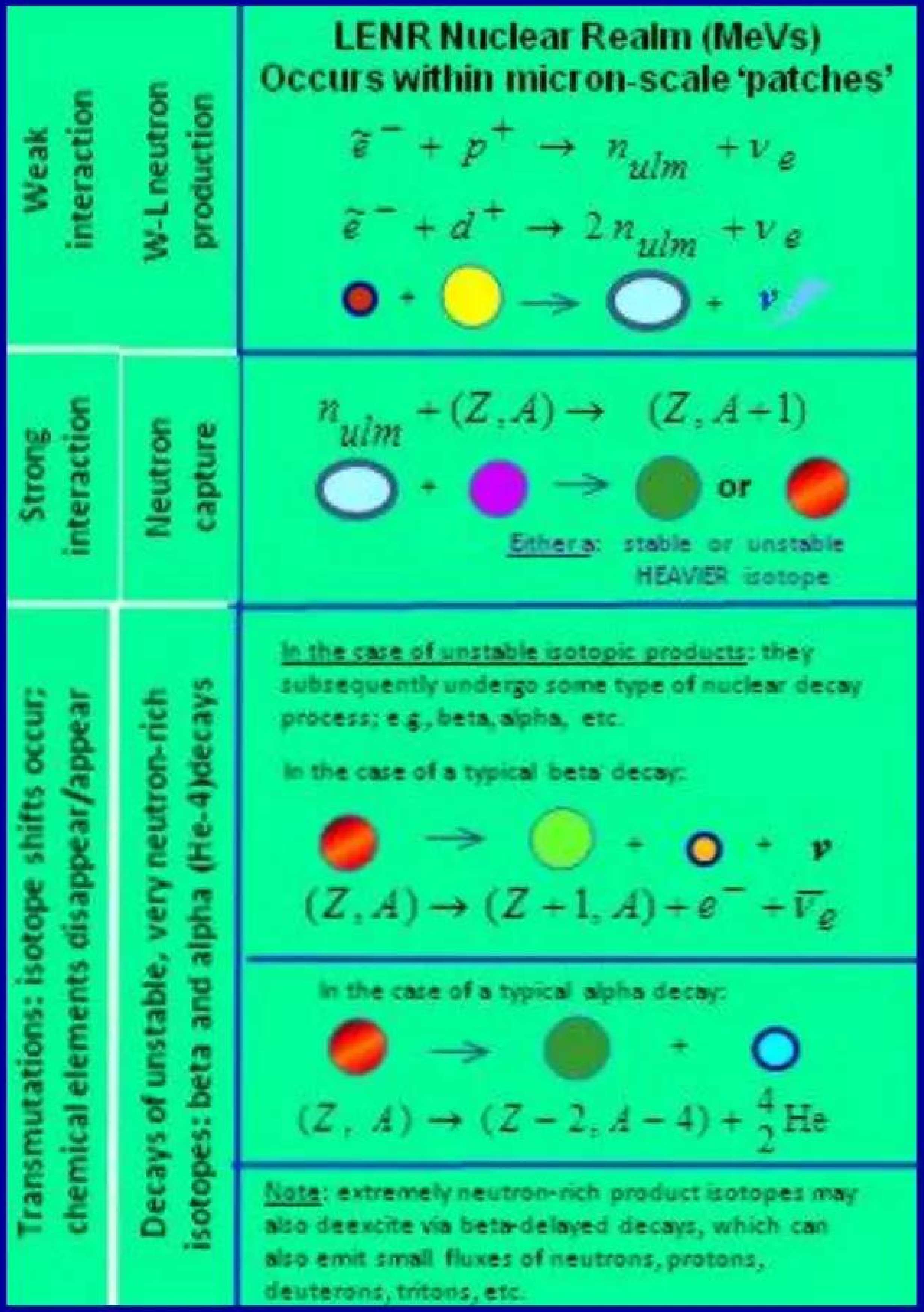
Now please recall the previous example for Oxygen:

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

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

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

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



LENRs in condensed matter systems and dusty plasmas

Consequences of local breakdown in chemistry assumptions - 6

Neutron capture cross-sections for H, C, N, and S isotopes:

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

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

<u>Carbon natural abundance</u>: ^{12}C = 98.93%; ^{13}C = 1.07%

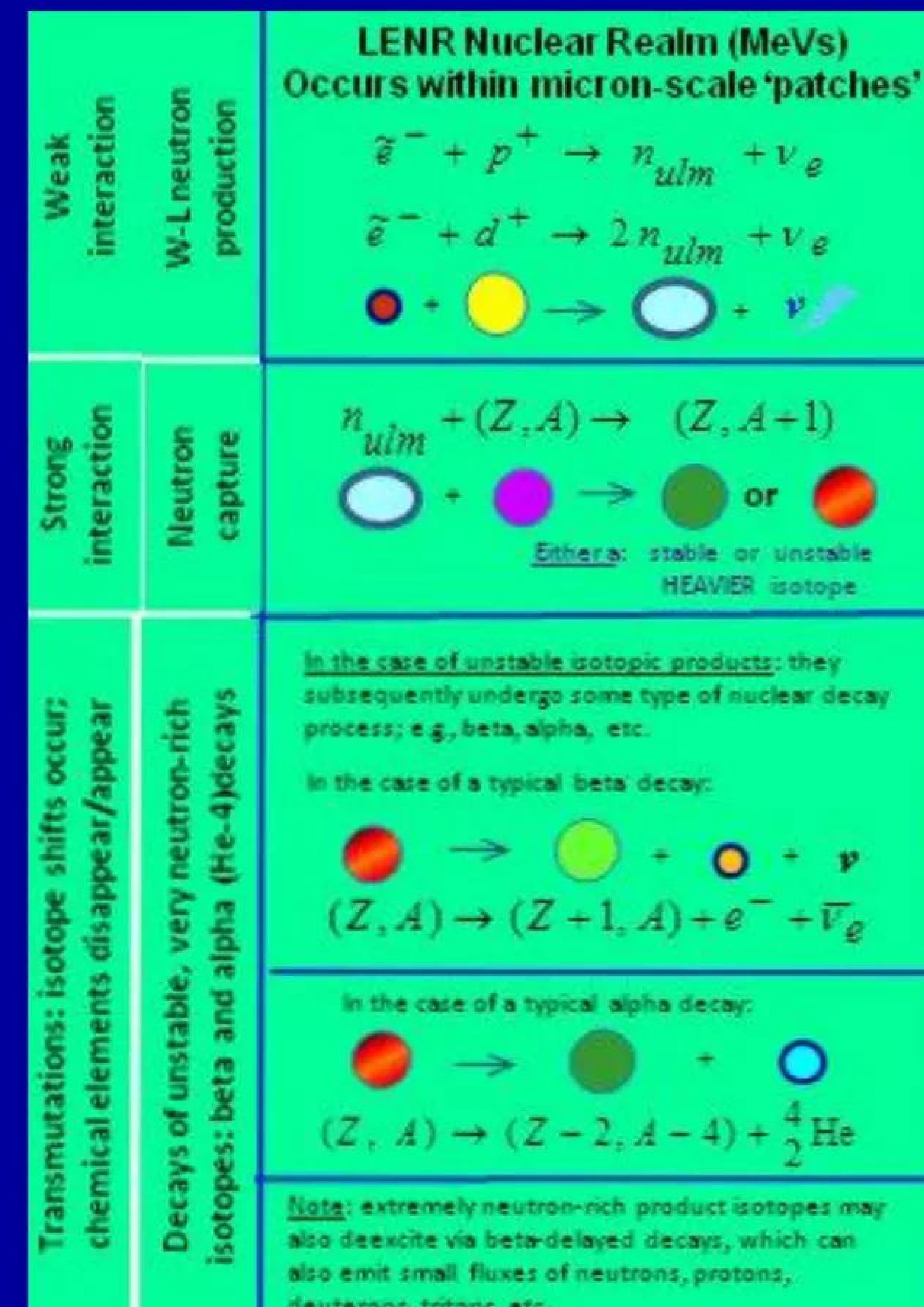
At thermal energies, ^{12}C has a neutron capture cross-section of only ~3.5 millibarns; at ULMN energies it is probably >3,000 barns since ^{12}C is a 1/v isotope. Thus, in LENR systems the reaction $^{12}C + n \rightarrow {}^{13}C + \gamma$ could in theory occur at substantial rates; again, capture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

<u>Nitrogen natural abundance</u>: ^{14}N = 99.632%; ^{15}N = 0.368%

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

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

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



LENRs in condensed matter systems and dusty plasmas

Consequences of local breakdown in chemistry assumptions - 7

- ✓ In most types of chemical catalysis, reactants and products must be in intimate nanoscale contact with a surface (often a metal of some sort) in order for a catalytic acceleration of reaction rates to occur.
- ✓ Hypothetically, what might occur if such reactions took place at tiny sites on a metal surface that also just happened to be located 'right on the edge' of a 30 micron 'patch' in which fluxes of LENR ULM neutrons were being produced? Well, according to the W-L theory all the atoms comprising any of the reactants (which are not necessarily 100% consumed) or products found in such locations would have an opportunity to 'compete' (with many thousands of other atoms located in and adjacent to the patch) to capture ULM neutrons. At low fluxes, typically only one ULM neutron might be captured by a given 'target' atom. That would tend to deplete lower-mass isotopes and enrich higher-mass isotopes; i.e., in above examples one could conjecture that $\delta\ ^{15}$N, $\delta\ ^{18}$O**,** $\delta\ ^{13}$C and δ D would all tend to <u>increase</u>
- ✓ All other things being equal, repeated or protracted exposure of molecular H, C, N, O, or S atoms to local fluxes of ULM neutrons would most likely tend to <u>increase</u> measured values for δD, $\delta\ ^{13}$C, $\delta\ ^{15}$N, $\delta\ ^{17-18}$O, and $\delta\ ^{34}$S; such LENR nuclear effects would be manifested as statistically significant variances from reference standards
- ✓ **At relatively <u>low</u> ULMN fluxes: LENRs might very well mimic mass-dependent chemical fractionation processes. At somewhat higher fluxes of captured neutrons, LENRs could potentially produce significantly larger stable isotope anomalies that would most likely exhibit no apparent relationship to mass; i.e., they would appear to be mass-independent**
- ✓ **At <u>high</u> local ULM neutron fluxes: several neutrons might be captured by a particular atom, creating an unstable, neutron-rich 'heavy' isotope that beta decays, producing a different chemical element which would then be available to participate in other chemical reactions. Such newly produced stable elements, which may or not have been previously present, could also mistakenly be regarded by researchers as 'outside contaminants' when they are really products of local LENR processes**

More questions, speculation, experimental opportunities - I

What are potential implications of WLS paradigm shift re nucleosynthesis

More investigation greatly needed: outstanding opportunities for experimentalists

Question: dates back to the 1960s --- does non-anthropogenic terrestrial Plutonium truly exist?

Question whether non-man-made, non-supernova, inherently unstable Plutonium really does exist somewhere in terrestrial environments began in USSR in 1960s and continued through 1970s and mid-1980s. Still unresolved, from ~1990 onward this notion has been totally dismissed by geochemists; now near-universally assumed that natural non-manmade Plutonium does not exist anywhere in terrestrial environments. **This idea supported by fact that longest half-life of *any* Plutonium isotope is Pu-244 at 80.8 million years**.

Apart from a lack of conclusive experimental data, an underlying part of the conceptual problem with accepting this possibility is that heretofore there has been no plausible abiological or biological mechanism capable of producing Plutonium isotopes from other elements under conditions that prevail on today's earth. However, as we have shown herein, natural terrestrial nucleosynthesis does occur, which means that creation of short-lived Plutonium may be possible. Once made, it disappears in an 'eye blink' of geological time.

That said, some older published experimental work may now need to be carefully reexamined; please see:

"Has element 108 been discovered?"
V. Kulakov
Atomic Energy **29** pp. 1166 - 1168 (1971)
Translated from *Atomnaya Energia* **29** pp. 401 - 402 (1970)
http://www.springerlink.com/content/p042g7671h185055/fulltext.pdf

Direct quotes: "Sergenium is genetically related to Pu^{239}. In some preparations of uranium isolated from molybdenite, and in some isolated rocks, including material from the upper mantle of the earth, V.V. Cherdyntsev has discovered an excess of that plutonium isotope. Clearly, Pu^{239} itself could not have been retained in nature up to the present day. But it could be formed in uraniferous ores in negligible quantities (~10^{-10} fraction of the U^{235} present) because of the presence of neutrons deriving from spontaneous fission of the uranium. **Any excess over that fraction means, in Cherdyntsev's view, that the Pu^{239} discovered in the minerals has accumulated as a result of the decay of its parent, which would have to be some more remote transuranium element (i.e., Sergenium).**"

More questions, speculation, experimental opportunities - II

What are potential implications of WLS paradigm shift re nucleosynthesis

More investigation greatly needed: outstanding opportunities for experimentalists

Question: dates back to the 1960s --- does non-anthropogenic terrestrial Plutonium truly exist?

Comments about the paper, "*Has element 108 been discovered?*" by V. Kulakov:

Prof. Viktor Cherdyntsev was a famous Russian geochemist with an excellent reputation and long experience who spent many years collecting experimental field data on Actinides found in Nature. He served on the staff of the Radium Institute of the Academy of Sciences of the USSR from 1930 to 1944 and on the staff of the Institute of Astronomy and Physics of the Academy of Sciences of the Kazakh SSR from 1944 to 1960. From 1946 to 1960, he was also the head of the subdepartment of experimental physics at the Kazakh University in Alma-Ata; he became a professor at the university in 1948. In 1960 he became the head of the laboratory of absolute age determination at the Geological Institute of the Academy of Sciences of the USSR in Moscow.

Cherdyntsev's main works dealt with the geochemistry of isotopes, nuclear geophysics, and radiogeology. Cherdyntsev was the first to substantiate the origin of heavy elements in massive stars. In 1954, together with P. I. Chalov, he discovered the spontaneous fission of the uranium isotopes ^{234}U and ^{238}U; the spontaneous fission of the two uranium isotopes is called the Cherdyntsev-Chalov effect. Cherdyntsev demonstrated the importance of radioactive and radiogenic isotopes, such as ^{4}He and ^{40}Ar, in the study of the earth's upper mantle.

By 1970, Cherdyntsev had been publishing field studies reporting anomalous 'natural' Plutonium in Russian language journals for years. Well aware of the comparatively short half-lives of Plutonium isotopes and worldwide bomb testing contamination issues, he was groping for a mechanism that could explain his data; at that time, no processes were known that could possibly create neutrons in terrestrial environments (natural fission reactors in were not discovered in Oklo, Gabon, until 1972). In April 1970, to explain his Pu^{239} data Cherdyntsev proposed the existence of a long-lived superheavy element 108, that he named "*Sergenium*," from which ^{239}Pu could hypothetically be produced over time via a decay chain.

Unfortunately, Cherdyntsev died in August 1971 at 59 years old, and was unable to continue in the debate with Academician G. B. Flerov and others who totally dismissed his ideas and data. ***While proposed "Sergenium" was later clearly proven to be wrong, most of Cherdyntsev's reported ^{239}Pu anomalies have never been satisfactorily explained, at least in our opinion.***

More questions, speculation, experimental opportunities - III

What are potential implications of WLS paradigm shift re nucleosynthesis

More investigation greatly needed: outstanding opportunities for experimentalists

Question: dates back to the 1960s --- does non-anthropogenic terrestrial Plutonium truly exist?

"***Geochemical isotopic anomalies and the hypothesis of natural nuclear reactors***"
R. Prasolov
Atomic Energy **36** pp. 61 - 83 (1974)
Translated from *Atomnaya Energia* **36** pp. 57 – 59 (1974)
http://www.springerlink.com/content/m5q0624066217t33/fulltext.pdf

Direct quotes: "Some experimental data have by now been accumulated concerning variations in the abundance of isotopes of a number of elements found in natural substances. For example, deviations of 3-20% from the Clarke isotope ratios have been observed in the case of ^{2}H, ^{13}C, ^{18}0, and other isotopes. These differences may be attributable to isotopic fractionation in gravitational and temperature fields, to diffusive and biogeochemical separation, and also to phenomena involved in evaporation and radioactive recoil following alpha disintegration [1-4]."

"However, in addition to the minor differences mentioned above, observations reveal some very substantial isotopic anomalies which are difficult or impossible to explain on the basis of the above-mentioned mechanisms. For example, isotopic variations of the order of 10^{3} - 10^{10}% [1, 3-9] have been observed in the case of isotopes of helium, neon, xenon, samarium, plutonium, and other elements. One of the most probable reasons for such large deviations may be the occurrence of various nuclear reactions, including reactions of the (n, γ) type, in natural neutron fields, as the result of cosmic radiation, spontaneous fission of heavy nuclei, and other neutron-generating processes, which have been discussed in [3, 5]. It must be noted that some studies for determining the value of the natural neutron background (in particular, on the basis of the accumulation of fission-produced xenon in minerals) have shown a discrepancy between the calculated and measured values of the background, with the calculated neutron flux sometimes greater by several orders of magnitude than the measured value."

"**In the light of these facts, an explanation of the observed anomalies should be sought on the basis of the hypothesis of natural nuclear reactors (NNR) [3, 5, 8, 10, 11]; the anomalies conform to the laws deduced from this hypothesis.** In particular, if other conditions are equal, there should exist a correlation between the effective neutron cross section and the value of the isotopic deviation for each particular isotope. We give below the results of a study bringing out such a correlation in the form of a single-parameter function $\varphi = f(\sigma)$; this is only a crude first approximation and does not take into account the length of time the neutron field has been acting, the probable migration of isotopes under geophysicochemical influences, and other factors."

More questions, speculation, experimental opportunities - IV

What are potential implications of WLS paradigm shift re nucleosynthesis

More investigation greatly needed: outstanding opportunities for experimentalists

Comments about the paper, "*Geochemical isotopic anomalies and the hypothesis of natural nuclear reactors*" by R. Prazolov:

What Fig. 1 shows is that, for the specific array of isotopes selected by Prasolov, there appears to be a reasonably well-behaved relationship between increased effective neutron cross-sections σ of the (n, γ) 'simple' capture reaction versus increased relative isotopic deviations φ as calculated by Prasolov. ***This type of causal relationship would be expected if W-L LENR ULM-neutron catalyzed transmutation processes, not just chemical fractionation, were occurring to some indeterminate degree somewhere in or around the earth.***

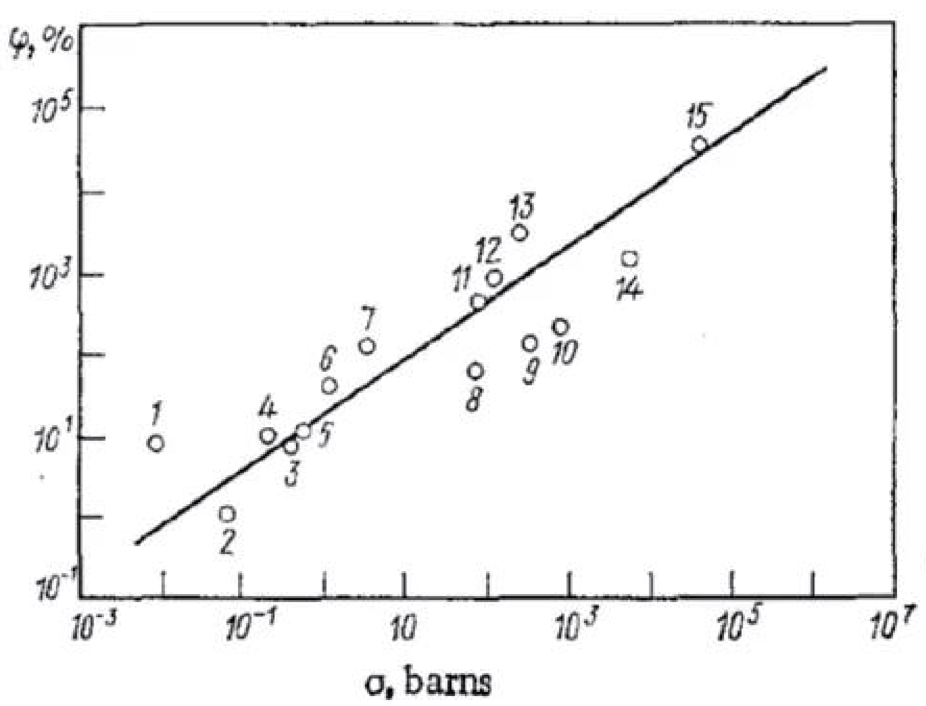


Fig. 1. Relative isotopic deviations as a function of effective neutron cross sections of the (n, γ) reaction: 1) ^{13}C; 2) ^{15}N; 3) ^{18}O; 4) ^{34}S; 5) $^{24}Mg/^{26}Mg$; 6) $^{87}Sr/^{86}Sr$; 7) $^{148}Nd/^{150}Nd$; 8) $^{144}Nd/^{145}Nd$; 9) ^{235}U; 10) $^{6}Li/^{7}Li$; 11) $^{140}Ce/^{142}Ce$; 12) $^{234}U/^{238}U$; 13) $^{143}Nd/^{142}Nd$; 14) $^{151}Eu/^{153}Eu$; 15) $^{149}Sm/^{147}Sm$.

Incredibly, to our knowledge Prasolov's intriguing ideas about the likely existence of "*natural reactors*" were never really picked-up and embraced by other researchers; they were generally believed to be very rare *a la* Oklo. Furthermore, although there had been spirited back- and forth discussion of this topic for twenty years or so, consensus turned decisively negative in the mid-1980s. At that time, based mainly on extrapolation of elemental/isotopic data from rain and snow samples collected at *one* location in Fayetteville, Arkansas, as well as other selected data, Prof. Paul Kuroda *et al.*, then of the Chemistry Dept. at the University of Arkansas, published two papers summarily dismissing the reported anomalous data of Cherdyntsev and others, concluding with sweeping assertions that essentially *all* Plutonium found on earth was simply the result of man-made atmospheric fallout contamination. The R&D thread dating back Cherdyntsev to appears to have totally died-out after ~1990. ***However, even the hardcore skeptics conceded that anomalous Plutonium was apparently emanating from volcanoes.***

More questions, speculation, experimental opportunities - V

Extraordinary Nitrogen isotope anomalies in Isheyevo primordial chondrite - I

- ✓ If non-stellar WLS nucleosynthesis were true, and if these LENR processes were associated with PAHs and occurred on surfaces of dust particles present in the early solar system *ca.* 3 – 4.5 billion or so years ago, what isotopic evidence of such LENR transmutations might be observed today?
  - **Criteria 1:** such isotopic anomalies produced by LENRs should be found in micron-scale 'patches,' probably no larger than 50 - 300 microns in diameter, located on the surfaces of so-called 'primordial grains' of material (xenoliths) embedded in somewhat younger, thermally processed materials comprising meteoritic bodies such as chondrites
  - **Criteria 2:** residues of some sort of organic carbon-based molecules (especially PAHs) should also be detected in some fashion at such localized sites
  - **Criteria 3:** if LENRs took place with ULM neutrons being captured by PAH ring carbon atoms located in PAH 'patches' on nebular dust grain surfaces, Nitrogen should be produced by the W-L Carbon-seed nucleosynthetic network. **Similar to the coke ovens at a South African steelmaking facility studied by an IAEA nuclear forensic team, there should also be significant enrichment of neutron-rich ^{15}N in such locations and accordingly anomalous $^{14}N/^{15}N$ isotopic ratios at those same localized sites**
- ✓ **Just such local anomalies involving neutron-rich ^{15}N meeting all of these criteria were observed and reported in a paper by Briani *et al.* that was published in the *PNAS* in May 2009, "*Pristine extraterrestrial material with unprecedented nitrogen isotopic variation*"**

Commercializing a next-generation source of CLENR energy

More questions, speculation, experimental opportunities - VI

Extraordinary Nitrogen isotope anomalies in Isheyevo primordial chondrite - II

- ✓ **Isotopic data reported in Briani *et al.'s* paper is truly fascinating.** To collect the data, they utilized a unique, multi-million $ mass spectroscopy instrument, a CAMECA NanoSIMS 50, that has the ability to perform detailed isotopic analyses on surface 'spots' down to 50 *nm* in size

- ✓ **Quoting:** "Pristine meteoritic materials carry light element isotopic fractionations that constrain physiochemical conditions during solar system formation. Here we report the discovery of a unique xenolith in the metal-rich chondrite Isheyevo … PX-18 is a dark xenolith (380 x 470 microns^2), dominated by a very fine-grained matrix, mainly composed of anhydrous Mg-rich silicates with tiny Fe-Ni sulfides grains and magnetite … In addition to the diffuse distribution of ^{15}N-enriched material, forty-six ^{15}N hotspots with extremely high $^{15}N_{AIR}$ were observed in PX-18 (Fig. 2B). These hotspots, with areas of approximately 1 micron^2, are distinct from the aforementioned, broad ^{15}N-enriched zones … These hotspot subregions are the highest $^{15}N_{AIR}$ values ever measured in solar system material … Together, these observations lead to the conclusion that ^{15}N hotspots in PX-18 are due to the presence of organic matter (OM)."

- ✓ **Comment: as predicted, they observed a high localization of ^{15}N isotope anomalies in micron-scale 'hot spots' that were clearly associated with organic matter. Briani *et al., who* could not fully explain the anomalies with "fractionation" processes, concluded, "*The results call for a new theoretical and experimental approach*."**

Please see:

"Pristine extraterrestrial material with unprecedented nitrogen isotopic variation"
G. Brianiet *et al.*
***PNAS* 10.1073 – pnas 0901545106 (2009)**

The 6-page article can be purchased from PNAS for $10 and downloaded from the following URL:

http://www.pnas.org/content/early/2009/06/15/0901546106.abstract

A free package of supplementary technical information may be downloaded from:

http://www.pnas.org/content/suppl/2009/06/15/0901546106.DCSupplemental/0901546106SI.pdf

A free copy of a conference presentation summary may be downloaded from:

http://www.lpi.usra.edu/meetings/lpsc2009/pdf/1642.pdf
[two Figs. from this appear on the next Slide]

Quoting from the abstract: "An extreme continuum of N isotopic variation is present in this xenolith: from very light N composition similar to that inferred for the solar nebula to the heaviest ratios measured in any solar system material."

More questions, speculation, experimental opportunities - VII

Extraordinary Nitrogen isotope anomalies in Isheyevo primordial chondrite - III

Quoting from their conference presentation: "These observations lead to the conclusion that ^{15}N isotopic variation in PX-18 are due to the presence of diffuse organic matter with a range in $\delta^{15}N^{AIR}$ that greatly expands the range for a single extraterrestrial object or isolated IOM. Excluding a stellar nucleosynthesis origin (i.e. related to presolar grains) for the observed N isotopic anomalies, values of $\delta^{15}N^{AIR}$ as high as those observed in PX-18 can be produced only by low-temperature ion-molecule reactions. In the most recent model for N-containing molecules chemistry under dark molecular cloud conditions, values of $\delta^{15}N^{AIR}$ > 9000‰ are obtained for external layers of NH^3 ice accreted on dust grains. Transfer of fractionated N from NH^3 ice to organic matter is possible by UV-induced transformations in polycyclic aromatic hydrocarbons. **However, a fundamental problem is that low temperature ion-molecule reactions are also predicted to produce strong deuterium enrichments in organic matter [17], which are not found in Isheyevo PX-18 or any other xenolith in Isheyevo. These results call for a new theoretical and experimental approach, which must be able to provide an explanation for the decoupling of these light elements isotopic variations as well as for the high values measured in the hotspots."**

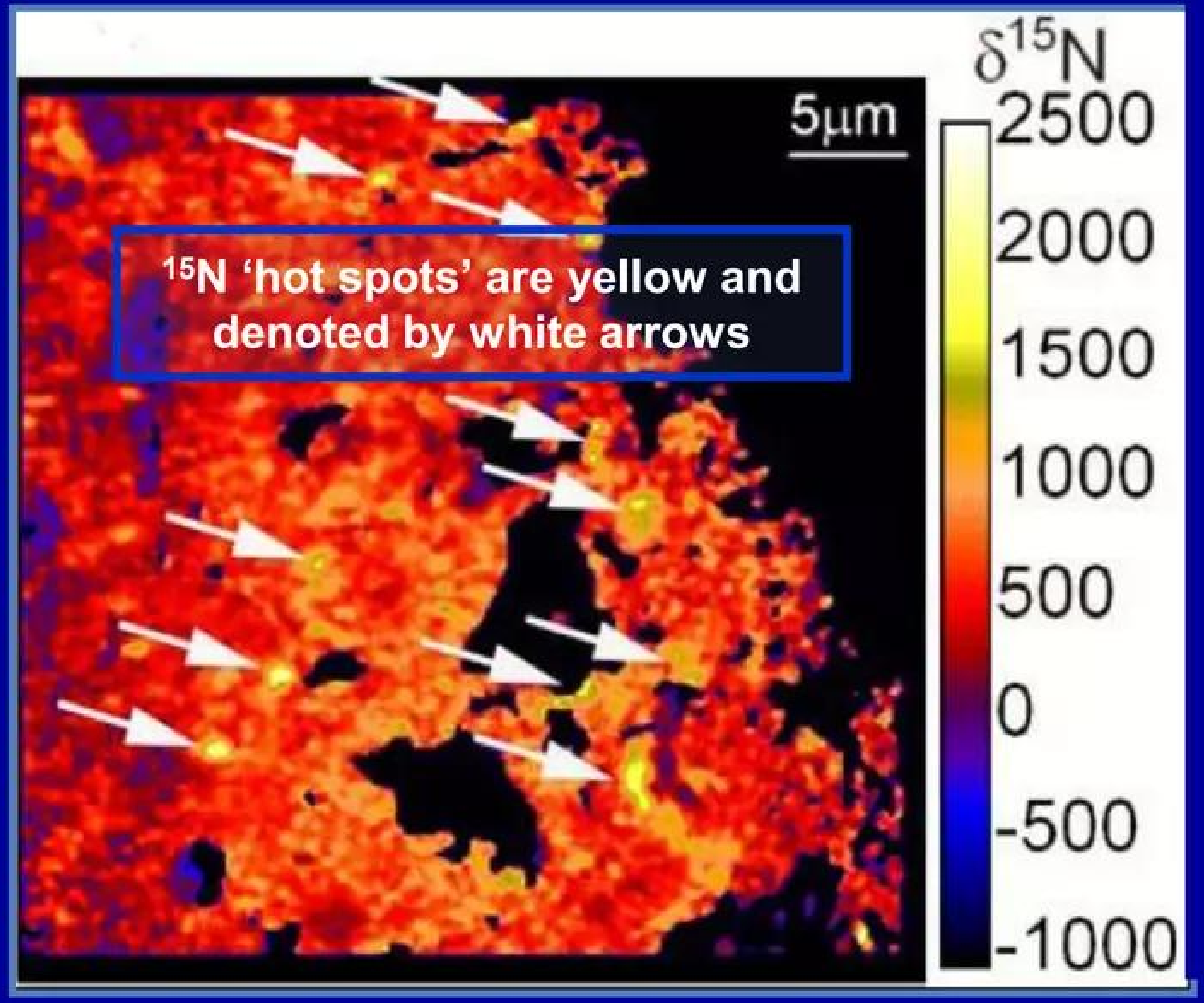


Figure 2. $\delta^{15}N^{AIR}$ distribution of a 40×40 μm² region in PX-18, with mean $\delta^{15}N^{AIR}$ = 640 ± 11‰. About 90% of this image is characterized by $\delta^{15}N^{AIR} \geq$ 250‰. Several hotspots are also visible (white arrows).

Source: http://www.lpi.usra.edu/meetings/lpsc2009/pdf/1642.pdf

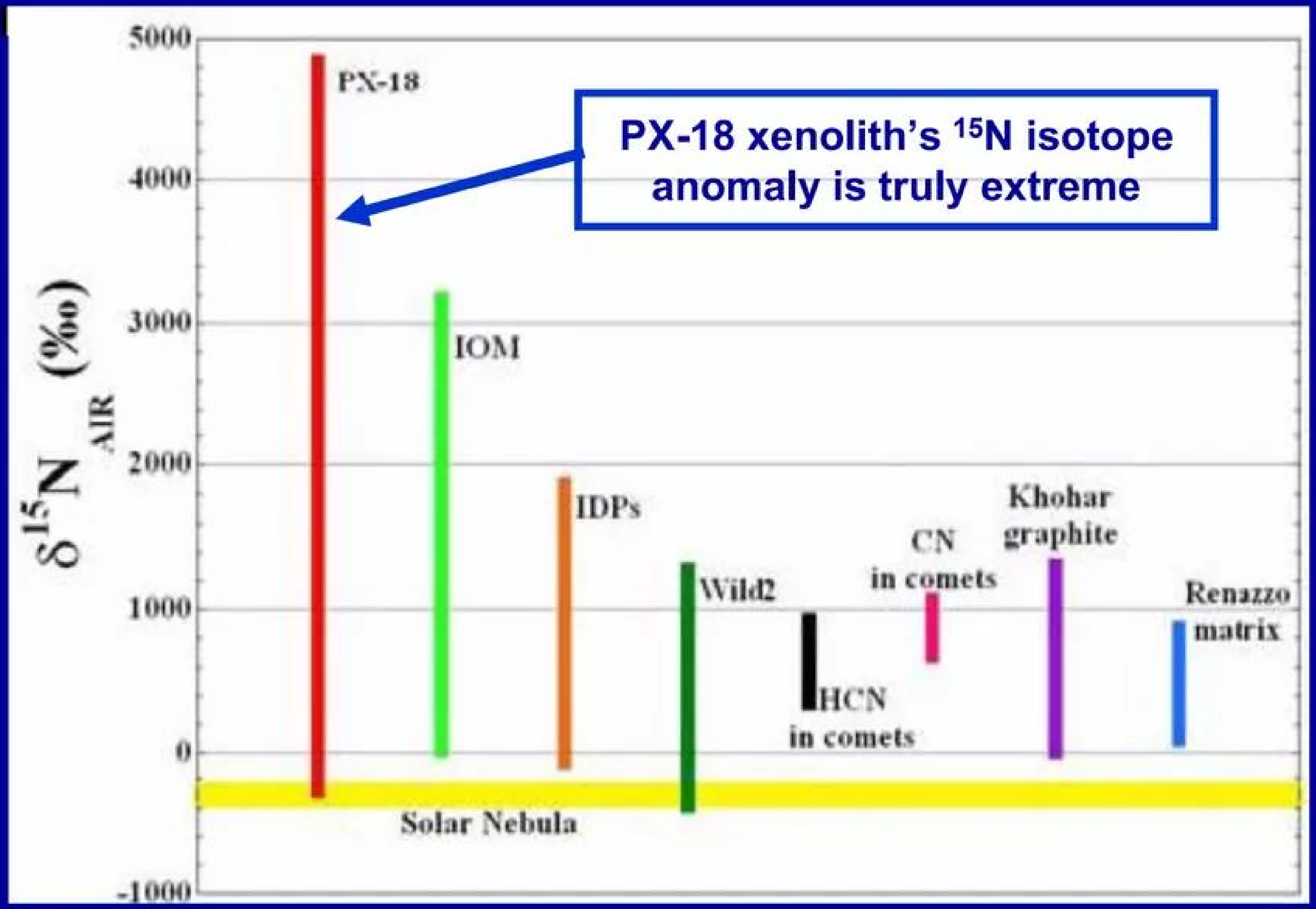


Figure 3. $\delta^{15}N^{AIR}$ values measured in PX-18, compared with previous measurements in other Solar System materials. Ranges reported in figure comprise results from bulk measures as well as from hotspots (data from literature).

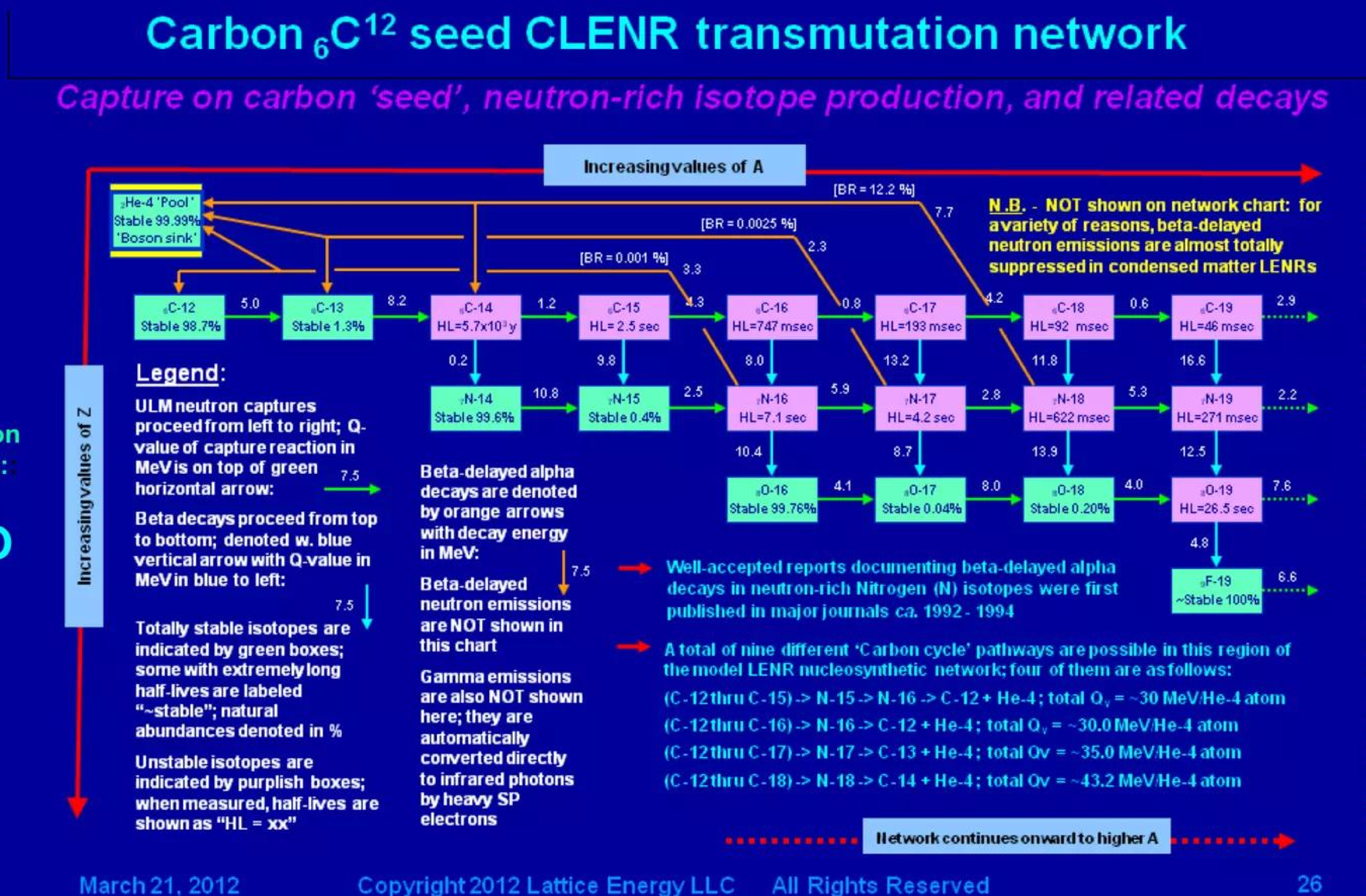
Commercializing a next-generation source of CLENR energy

More questions, speculation, experimental opportunities - VIII

Is LENR Carbon-seed nucleosynthetic network presently operating on earth?

LENR transmutation of stable elements::

C → N → O



Given appropriate energy inputs and starting conditions, this LENR network is capable of producing gaseous elemental N_2 and O_2 from Carbon molecules such as 6-Carbon aromatic (benzene) rings or PAHs. Elemental Carbon can thus 'disappear' by capturing LENR neutrons and reappear in the form of other, heavier, elements such as Nitrogen and Oxygen. In such situations, stable elements are not 'conserved' as in the case of purely chemical systems.

What are respective contributions of LENRs vs. chemical processes to elemental/isotopic abundances?

More questions, speculation, experimental opportunities - IX

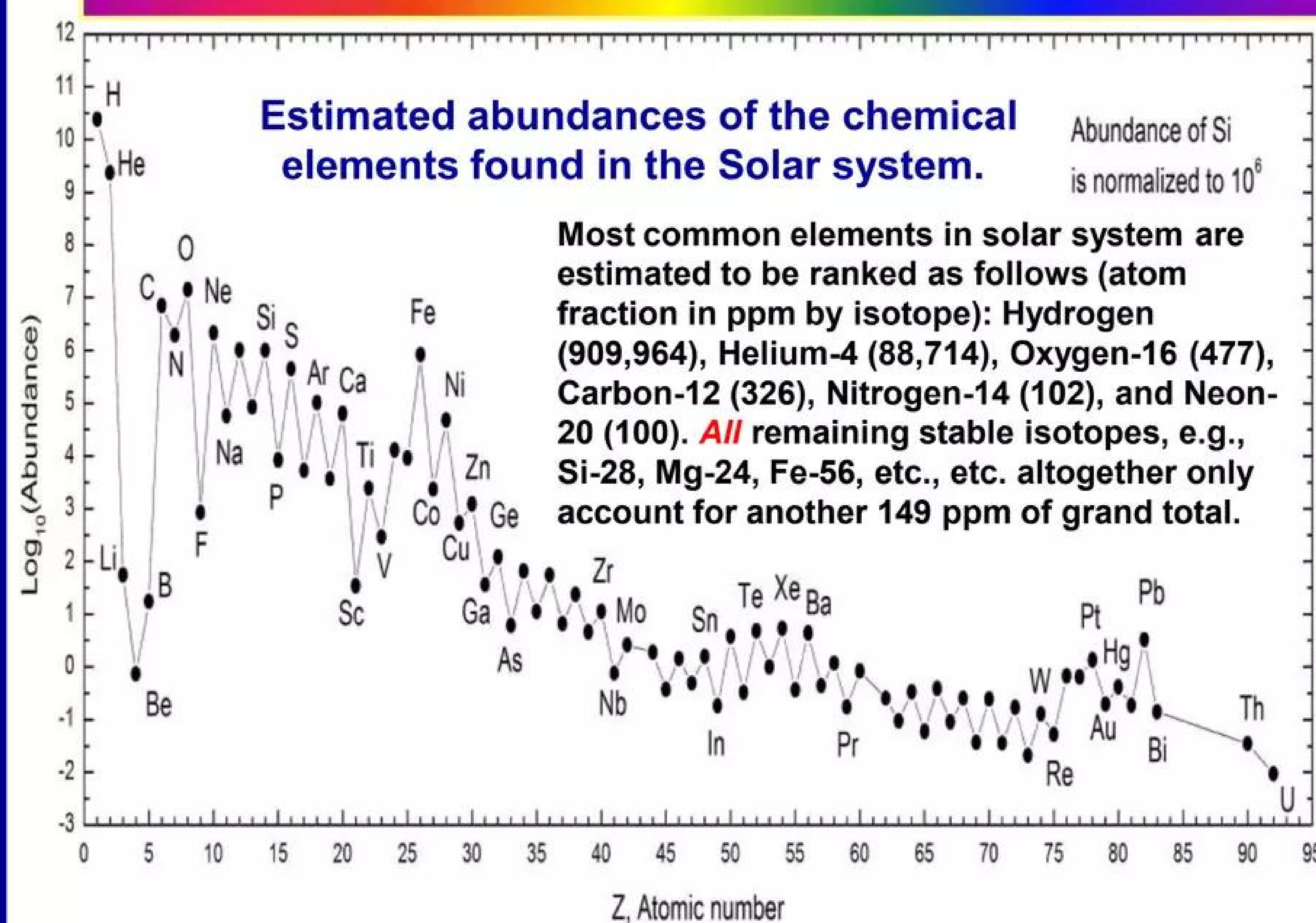
If other LENR networks have been operating on earth, what are consequences?

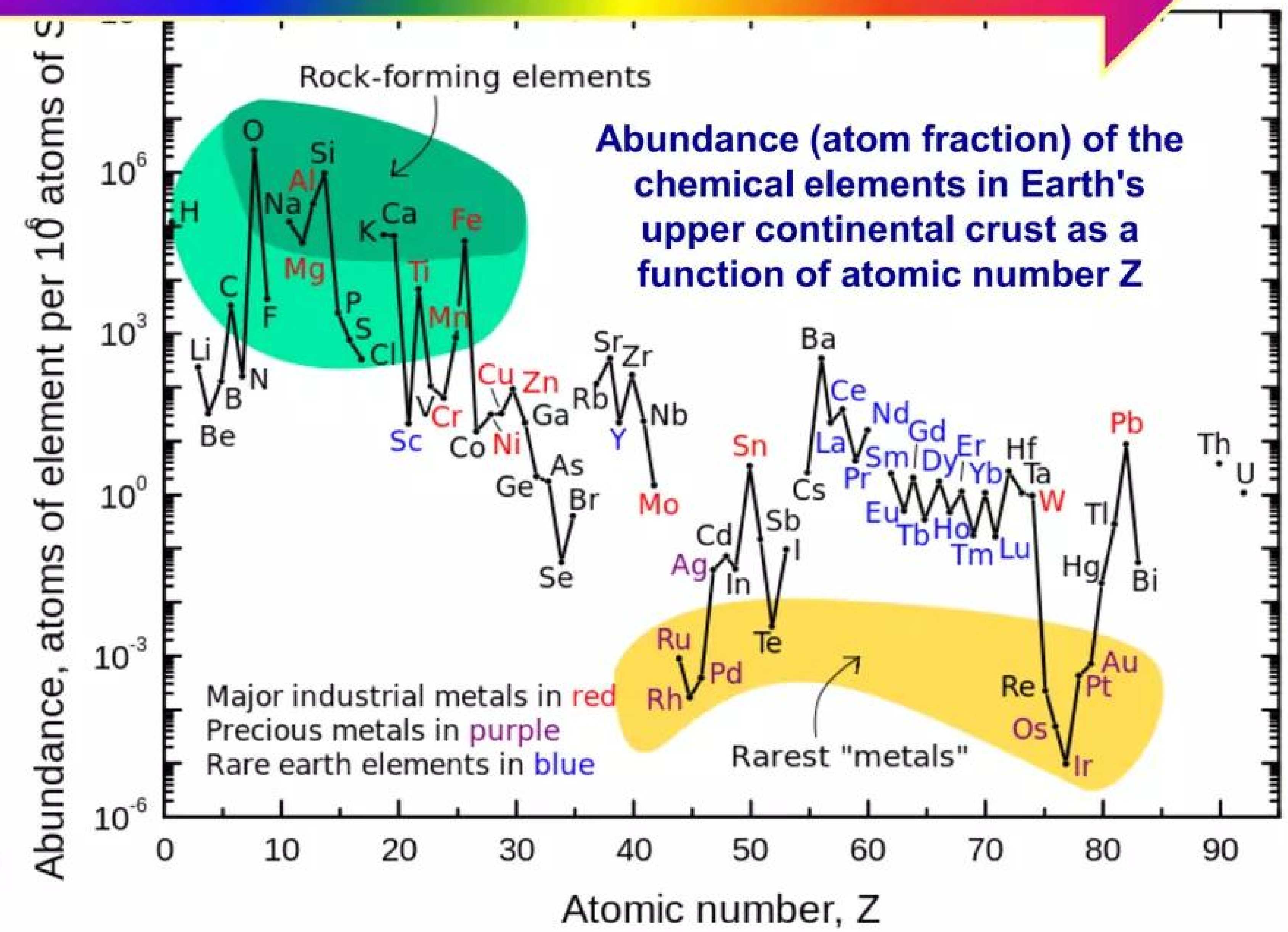
More investigation greatly needed: many outstanding opportunities for experimentalists

<u>Question</u>: do LENRs contribute to differences between solar vs. earth elemental/isotopic abundances?

When provided with sufficient and appropriate forms of energy input, LENR neutron-capture-driven transmutation networks will tend to create progressively heavier chemical elements over time, i.e., higher values of Z as shown in two charts below. At very least, lightning-driven WLS neutron production and capture processes have likely been occurring at non-zero rates since the days of the presolar nebula, before earth had even formed as a recognizable planet. If that were true, are puzzling Oxygen and Nitrogen isotopic anomalies revealed in the Genesis Mission data partly a result of such LENR processes operating over geologic time intervals? Many more experimental measurements must be made to answer this key question.

LENR transmutation processes may have been occurring at low rates in and around the earth for >4.5 x 10^9 years





More questions, speculation, experimental opportunities - X

If other LENR networks have been operating on earth, what are consequences?

More investigation greatly needed: many outstanding opportunities for experimentalists

Question: if earthly bacteria were utilizing LENRs, could correlated isotopic shifts be measured?

Excerpt from 50-page document cited to right:

Old paradigm - *Earth's Uranium isotope ratios are essentially invariant*:
Up until relatively recently, it was widely presumed that present-era $^{238}U/^{235}U$ ratios were, within some characteristic range of natural variance, essentially identical throughout the planet earth and its environs.

Obvious exceptions to the above 'rule' were ancient Oklo-type natural fission reactors, man-made stable and unstable isotopes produced in fission reactors and detonations of nuclear weapons, as well as captured interstellar debris produced during 'nearby' supernova explosions.

New experimental evidence - *challenges the old paradigm*:
Recently, greatly increased use of various types of mass spectroscopy by geochemists, microbiologists, and environmental scientists has revealed that the longstanding assumption of effective natural uniformity of $^{238}U/^{235}U$ ratios across the earth is clearly erroneous; importantly, present-era abiological and/or biologically mediated processes appear to be responsible for such anomalous variances.

Question - *how might significant changes in $^{238}U/^{235}U$ ratios occur?*
Are anomalous variances in such isotopic ratios the result of purely chemical "fractionation" process or processes of some sort, and/or could they be caused by low energy nuclear reactions (LENRs), either abiologically or somehow induced by the actions of bacteria through some yet to be clarified mechanism?

Please see:

"Some bacteria appear capable of altering isotopic ratios of Uranium --- Is it the result of prosaic chemical fractionation processes and/or LENRs?"
L. Larsen
Lattice Energy LLC
50-page Technical Document [not peer-reviewed]
December 7, 2010
http://www.slideshare.net/lewisglarsen/bacteria-lenrsand-isotopic-shifts-in-uraniumlarsenlattice-energy-dec-7-2010-6177275

Summary: provides description of theoretical W-L LENR Actinide nucleosynthetic network and selected examples of published mainstream, peer-reviewed experimental data which report anomalous isotopic shifts clearly associated with the metabolic activities of bacteria --- some or all of the hypothesized network pathways are potentially present in soils, ocean sediments, dusty chemical explosions, volcanic eruptions, and extraterrestrial impact events

More questions, speculation, experimental opportunities - XI

If other LENR networks have been operating on earth, what are consequences?

More investigation greatly needed: many outstanding opportunities for experimentalists

See Wikipedia article (source of graph at lower right):
http://en.wikipedia.org/wiki/Great_Oxygenation_Event

"Missing Nitrogen" mass-balance problem in ecosystems:

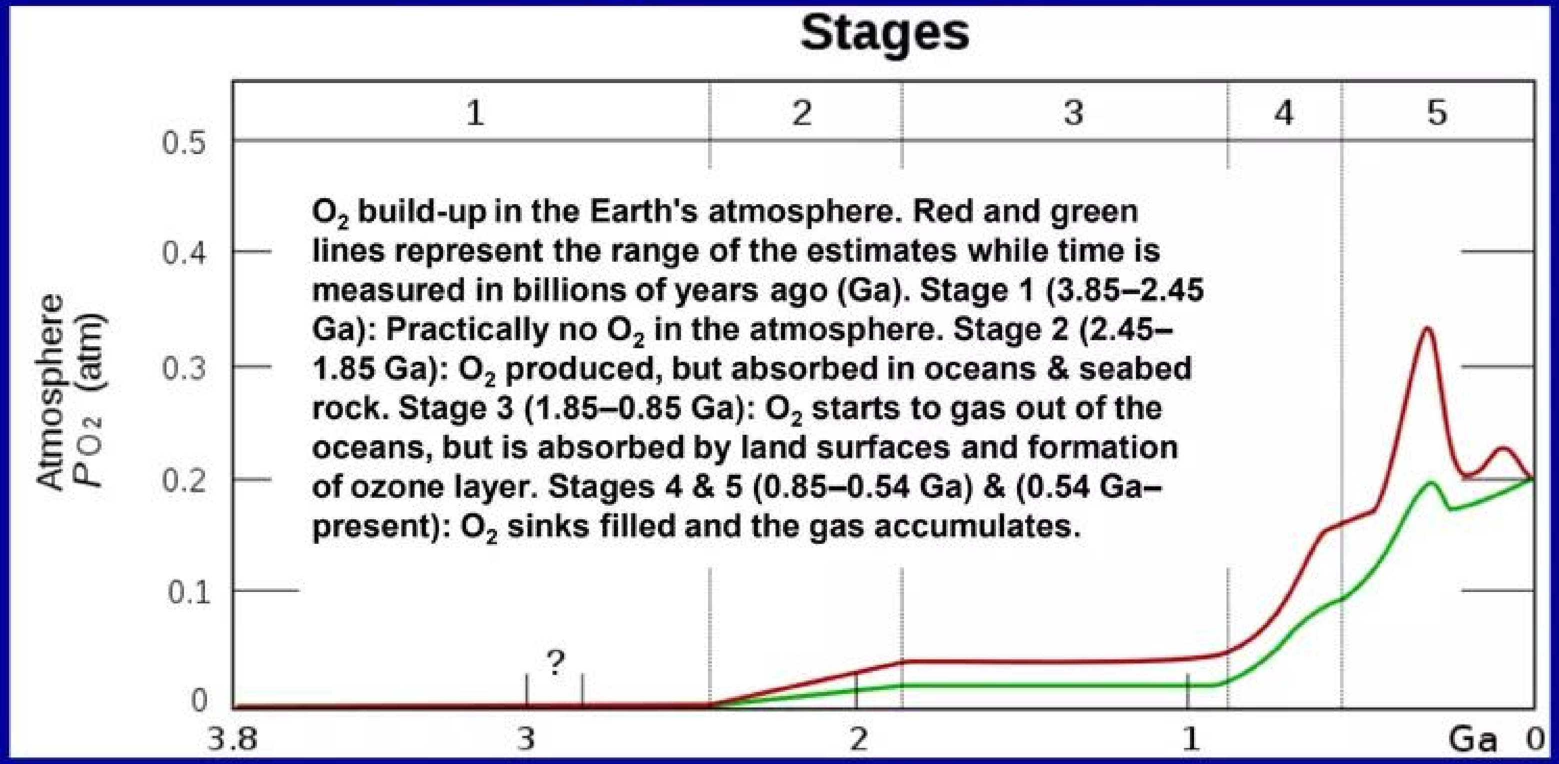
For ~60 years there has been a persistent issue with the mass-balance of total Nitrogen inputs vs. outputs in many terrestrial ecosystems. Specifically, when one measures all the known Nitrogen inputs as best possible and then measures all known outputs from a given system under study, there can often be significant shortfalls in output vs. input: Nitrogen seems to 'disappear' and its measured mass-balance is thus 'off.' Heretofore, it has been universally assumed that this was merely a measurement issue in which Nitrogen in some chemical species was 'escaping' the defined confines of the analysed system without being 'trapped' and quantitatively measured (e.g., as gaseous N_2). **However, even with much better measurement techniques, this mass-balance anomaly keeps cropping-up in many different studies and on a huge range of different spatial scales, from entire regional watersheds down to individual lakes. Thus the anomaly still persists. Well, perhaps it is real and just maybe LENRs have something to do with it?**

Let's assume that Nitrogen is sometimes truly missing in Nature, i.e., it mysteriously disappears; could that effect be causally related to earth's Great Oxygenation Event?: if multiple species of microorganisms presently living in terrestrial ecosystems have an ability to use LENRs to transmute Nitrogen into other stable elements, it would readily explain the longstanding Nitrogen mass-balance problem. If that speculation is correct, such a capability would have had to evolve at some earlier point in earth's history: could that have been around the time of Great Oxygenation Event?

"Biological activity and the Earth's surface evolution: Insights from carbon, sulfur, nitrogen and iron stable isotopes in the rock record"
C. Thomazo *et. al.*
C. R. Palevol. **8** pp. 665 - 678 (2009)
http://www.geotop.ca/pdf/pintiD/Thomazo_et_al_CRP_2009.pdf

Quoting: "Major changes of C, N, S and Fe isotopic compositions are recorded between ~2.8 and ~2.5 Ga (Fig. 1) and can be interpreted in terms of environmental and associated-metabolic changes. The δ13 C measured in organic matter shows a large negative isotopic shift from −30‰ down to −60‰ and back to −30‰, while δ 56Fe values, which are mainly around 0‰ over the last 4 Ga show in this particular period a decrease down to −4‰ (Fig. 1). MIF-S show variations from −0.5 to +1.4‰ between 3.2 and 2.8 Ga, and a larger range, from −2.5 to +11.2‰, between 2.7 and 2.45 Ga before disappearing after 2.4 Ga. Negative δ 34 S values < −17‰ are also recorded at 2.7 Ga in the Belingwe belt (Zimbabwe). Finally, the δ 15N shows an extreme enrichment in 15N (from +24 up to +35‰) around 2.7 Ga compared to Paleoarchean δ 15N (between −7 and +7‰) and Proterozoic δ 15N (average of +5.6‰)."

Great Oxygenation Event (Earth)



Conclusions and final quotation

"Mystic Mountain" - Hubble Space Telescope image taken by Wide Field Camera 3 in February 2010; colors in this composite image correspond to the glow of oxygen (blue), hydrogen and nitrogen (green), and sulphur (red). This turbulent cosmic pinnacle, 3 light-years high, lies within a tempestuous stellar nursery called the Carina Nebula, located 7500 light-years away in the southern constellation of Carina. Scorching radiation and fast winds (streams of charged particles) from super-hot newborn stars in the nebula are shaping and compressing the pillar, causing new stars to form within it. The denser parts of the pillar are resisting being eroded by stellar radiation. Nestled inside this dense 'mountain' of complex dust and gas are fledgling stars; there are swirling discs of dust and gas around these young stars, which allow nebular material to slowly accrete onto their photospheric 'surfaces'.

If non-stellar WLS nucleosynthetic processes are as widespread as they appear to be, they are probably occurring at extremely variable rates in plasmas and on scattered heterogeneous dust grains distributed throughout such vast regions of Hydrogen- and radiation-rich space.

Credit: NASA, ESA, M. Livio and the Hubble 20th Anniversary Team (STScI)

Catatumbo River, Venezuela: most intense lightning activity

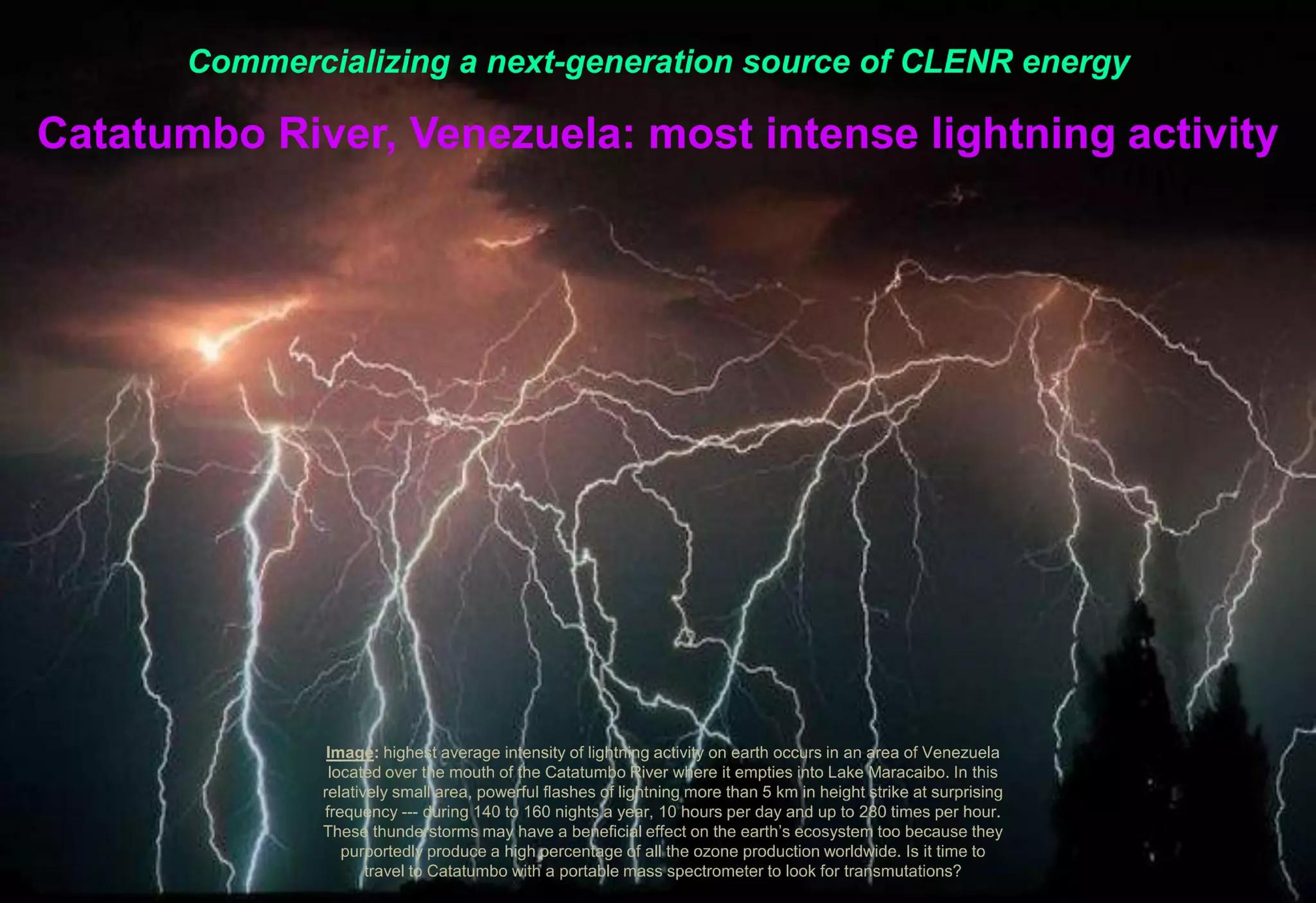


Image: highest average intensity of lightning activity on earth occurs in an area of Venezuela located over the mouth of the Catatumbo River where it empties into Lake Maracaibo. In this relatively small area, powerful flashes of lightning more than 5 km in height strike at surprising frequency --- during 140 to 160 nights a year, 10 hours per day and up to 280 times per hour. These thunderstorms may have a beneficial effect on the earth's ecosystem too because they purportedly produce a high percentage of all the ozone production worldwide. Is it time to travel to Catatumbo with a portable mass spectrometer to look for transmutations?

Conclusions

- ✓ Herein, we have discussed a plausible WLS mechanism whereby LENR nucleosynthetic processes could potentially occur in high-current atmospheric lightning discharges happening on Earth, as well as on other planets, moons (e.g., Io?), and large hydrogen-rich regions of dusty nebulae subjected to large fluxes of energetic photon and particle radiation emitted by nearby stars;
- ✓ Non-stellar nucleosynthesis could thus be occurring at widely varying rates in many more places around the Universe than any of us could have ever before imagined;
- ✓ This paradigm shift in thinking about nucleosynthesis opens-up huge new vistas for future research and promises further exciting insights into the long, rich pageant of planetary and galactic chemical evolution.

Lattice Energy LLC

Commercializing a next-generation source of CLENR energy

"I have walked that long road to freedom. I have tried not to falter; I have made missteps along the way.

But I have discovered the secret that after climbing a great hill, one only finds that
there are many more hills to climb.

I have taken a moment here to rest, to steal a view of the glorious vista that surrounds me,
to look back on the distance I have come.

But I can rest only for a moment, for with freedom comes responsibilities, and I dare not linger,
for my long walk is not yet ended."

Nelson Mandela
***Long Walk to Freedom* (1995)**

Eyjafjallajökull volcano in Iceland (2010)