Electroweak Neutron Production via $e + p \rightarrow n + \nu$ and Capture during Lightning Discharges

Lewis G. Larsen

Lattice Energy LLC, 175 N. Harbor Dr. #3205, Chicago, IL, lewisglarsen@gmail.com

INTRODUCTION

This paper is part of the panel session "Discussion of Low-Energy Nuclear Reactions." Enabled by many-body, collective effects and appropriate forms of required input energy (e.g., electric currents and/or organized magnetic fields with tubular geometries can be used to produce 'catalytic' neutrons via an electroweak reaction: $e + p \rightarrow n + \nu$), LENRs involve elemental nucleosynthetic transmutation reactions very much like stars, only at vastly lower temperatures and pressures that are found in laboratory apparatus such as electrolytic chemical cells and many natural processes such as lightning discharges.

WIDOM-LARSEN THEORY AND LIGHTNING

Derived from extension of the exploding-wire case explained in our theoretical work, the Widom-Larsen theory of LENRs[1, 2] strongly predicts that significant, detectible neutron fluxes will be produced via an electric current-driven electroweak reaction mechanism during ordinary lightning discharges that occur in earth's atmosphere. Presumably this type of neutron production could also occur during intense lightning activity closely associated with dusty terrestrial volcanic eruptions and extraterrestrial object impact events, as well as similar types of lightning discharges occurring on other planetary bodies in the solar system, e.g., Jupiter, Saturn, etc.

Vast majority of mostly low-energy LENR neutrons produced in such lightning discharges would likely be captured by nearby atoms before newly created free neutrons can decay (half-life of a free neutron is ~13 minutes); LENR neutron-catalyzed nucleosynthesis at low rates could thus have been occurring at variable rates in earth's atmosphere for as long as ~4.5 billion years.

RUSSIAN DATA CONFIRMS WIDOM-LARSEN

Gurevich *et al*.[3] recently published new experimental data which clearly showed neutron production in lightning, exactly as predicted by the Widom-Larsen theory. Summarizing, they stated that, "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."

Since 1985 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 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 nuclear fusion processes had been decisively excluded in years prior to a recent rise in popularity of the conjectured photonuclear mechanism, e.g., Babich & R-Dupre[4], the Widom-Larsen many-body, collective magnetic $e + p \rightarrow n + \nu$ electroweak reaction mechanism is the only remaining theoretical approach that can successfully explain key features of this new experimental data on production of neutrons in lightning.

ISOTOPIC 'FRACTIONATION' IN ATMOSPHERE

Nitrogen (N_2 ~78% vol.) and Oxygen (O_2 ~21%) are the most common gases in earth's atmosphere. That being the case, excluding neutron captures on elements located in trapped dust particles, they could easily capture most LENR neutrons created in ordinary lightning discharges.

There are numerous published experimental observations of 'fractionation' of Oxygen and Nitrogen isotopes found in atmospheric air. Is this strictly resulting from chemical processes or could LENRs be involved?

Interestingly, atmospheric lightning discharges are well-known to be major producers of both Ozone (O_3) and NO_x; a single very large lightning bolt is thought to produce as much as several hundred pounds of Ozone.

NEUTRON-CAPTURE ON GASEOUS NITROGEN

Nitrogen's natural abundance is $^{14}N = 99.632\%$; $^{15}N = 0.368\%$. At thermal energies, ^{14}N has a neutron capture cross-section of only 0.080 barns; at LENR ultra low momentum neutron energies it may be 10^5-10^6x larger because ^{14}N is a $1/v$ isotope. Thus, in LENR systems the reaction $^{14}N + n \rightarrow {}^{15}N + \gamma$ can potentially proceed at significant rates; capture gammas would not be detected because of conversion to IR by local heavy-mass electrons per Widom-Larsen theory. Neutron 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 LENR neutron fluxes ^{15}N should accumulate faster than it can be transmuted via neutron capture into ^{16}N. *All other things being equal, over time LENRs would tend to create increases in $\delta^{15}N$ and magnitude of isotopic variance.*

NEUTRON-CAPTURE ON GASEOUS OXYGEN

Oxygen's natural abundance is $^{16}O = 99.759\%$; $^{17}O = 0.0374\%$; $^{18}O = 0.2039\%$. 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 LENR neutron-catalyzed processes: (1.) neutron capture to ^{18}O; and (2.) alpha (^4He) decay to Carbon-14 (^{14}C). Those competing processes are probably the reason why ^{17}O has lower natural abundance than ^{16}O and ^{18}O. *All other things being equal, exposure of gaseous Oxygen atoms to LENR neutrons would tend to increase $\delta^{18}O$ and magnitude of isotopic variance.*

MASS-INDEPENDENT FRACTIONATION

First seen in Sulfur isotopes, concept of "mass-independent" isotopic fractionation was originally developed to explain data exhibiting isotopic shifts that clearly did not conform to a purely chemical, mass-dependent kinetic effects paradigm. Present proponents of this explanation, e.g., Michalski & Bhattacharya[5], implicitly invoke purported "nuclear field shift," "nuclear volume, " and/or "symmetry" effects to provide a non-nuclear rationale for otherwise chemically inexplicable isotopic shifts observed with some isotopes and molecules of certain elements, e.g., Ozone (O_3), Sulfur, and very recently, Methylmercury.

CHEMICAL FRACTIONATION VS. LENRS

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.

Although not explicitly acknowledged by chemical fractionation theorists, an intrinsic *fundamental assumption* underlying this entire body of theory and interpretation of data is that no indigenous nucleosynthetic processes are presently occurring anywhere in any of these systems, or at any time since the initial formation of the presolar nebula, that are/were capable of altering isotope ratios and/or producing new mixtures of different elements over time; ergo, chemistry must explain everything. However, if the Widom-Larsen theory of LENRs is correct, for certain isotopic data the above fundamental assumption could potentially be incorrect. *Moreover, products of LENRs can mimic the effects of mass-dependent and mass-independent chemical fractionation processes.*

LENR NEUTRON-CAPTURE ON SULFUR ATOMS

Sulfur's natural abundances is $^{32}S = 94.93\%$; $^{33}S = 0.76\%$; $^{34}S = 4.29\%$; $^{36}S = 0.02\%$. 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 LENR ULM neutron fluxes, $\delta^{33}S$, $\delta^{34}S$, and $\delta^{36}S$ would all tend to increase; ^{35}S is unstable (half-life = 87 days) and beta- decays to ^{35}Cl. Higher ULM neutron fluxes could produce ^{37}S which is unstable (half-life = 5.1 minutes) and β^- decays into Chlorine ^{37}Cl (which is stable but *very* reactive). *Depending on details, LENRs could create isotopic shifts that looked as though mass-independent chemical fractionation had occurred.*

TERRESTRIAL GEOCHEMICAL EVOLUTION

Recent work of Nuth *et al.*[6] about lightning processing of dust particles in presolar nebula suggests that low but nonetheless significant rates of lightning-driven LENR nucleosynthesis could easily have been occurring in the environs of the solar system for >4.5 billion years. This more recent LENR transmutation activity would have been superimposed on top of nucleosynthetic reaction products originating from even more ancient episodes of stellar fusion processes and supernova events. *That being the case, are telltale isotopic 'signatures' of non-stellar LENR processes detectable and present in published isotopic data obtained from NASA's Genesis Mission?*

NASA GENESIS DISCOVERY MISSION DATA

In a published review of Genesis mission isotopic data on Oxygen, Burnett *et al*.[7] commented that, "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."

Regarding Nitrogen isotopic data, Burnett *et al.* said that, "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."

Burnett *et al.* finally concluded that, "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 ... 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."

CHEMICAL EVOLUTION OF SOLAR SYSTEM

Provided with sufficient and appropriate energy inputs, LENR neutron production/capture and β-decay transmutation processes will tend to create progressively higher-Z chemical elements over time. If lightning-driven LENR transmutation processes have truly been occurring at non-negligible rates since the era of the presolar nebula, before earth had even formed as a recognizable planet, then puzzling Oxygen and Nitrogen isotopic anomalies revealed in the NASA Genesis Mission's data could potentially have been caused by various LENR processes operating over geologic time intervals. That said, many more experimental measurements still need to be made in order to definitively answer this important question.

OPPORTUNITIES FOR FUTURE RESEARCH

Thanks to new conceptual insights provided by the Widom-Larsen theory of LENRs, non-stellar transmutation processes in terrestrial and presolar geochemical environments could be more interesting and dynamic than anyone could have ever imagined. Given that LENR-based transmutations may occur widely in Nature, there should be outstanding opportunities for curious researchers to discover many new and important details of LENR-driven biological and abiological nuclear processes and to develop valuable, new breakthrough commercial technologies from such discoveries.

REFERENCES

1. A. WIDOM AND L. LARSEN, "Ultra Low Momentum Neutron Catalyzed Nuclear Reactions on Metallic Hydride Surfaces," *European Physical J. C – Particles and Fields*, **46**, 107 (2006).
2. Y. SRIVASTAVA, A. WIDOM AND L. LARSEN, "A Primer for Electro-Weak Induced Low Energy Nuclear Reactions," *Pramana - J. of Physics*, **75**(4) 617 (2010).
3. A. GUREVICH et al., "Strong Flux of Low-energy Neutrons Produced by Thunderstorms," *Phys. Rev. Lett.,* **108**, 125001 (2012).
4. L. BABICH AND R. ROUSSEL-DUPRE, "Origin of Neutron Flux Increases Observed in Correlation with Lightning," *J. of Geophysical Research,* **112**, D13303 (2007).
5. G. MICHALSKI AND S. BHATTACHARYA, "The Role of Symmetry in the Mass Independent Isotope Effect in Ozone," *PNAS,* **106** (14), 5493 (2009).
6. J. NUTH et al., "Lightning Processing of Dust in the Solar Nebula," Presented at workshop on Formation of the First Solids in the Solar System (Kauai, Hawaii), LPI Contribution No.1639 9019 (2011).
7. D. BURNETT AND GENESIS SCIENCE TEAM, "Solar Composition from the Genesis Discovery Mission," *PNAS,* **108** (48), 19147 (2011).