ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/288002944

Synthesis of Neutrons from Hydrogen: The Conclusive Proof of LENR

Research · December 2015

DOI: 10.13140/RG.2.1.1479.9449

CITATIONS
0

READS
1,327

1 author:

Max Fomitchev-Zamilov
Maximus Energy Corporation

28 PUBLICATIONS **22** CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:

Project Nuclear Battery View project

All content following this page was uploaded by Max Fomitchev-Zamilov on 25 December 2015.

The user has requested enhancement of the downloaded file.

Synthesis of Neutrons from Hydrogen: The Conclusive Proof of LENR

Max I. Fomitchev-Zamilov[1], Ph.D.

[1] Quantum Potential Corporation, max@quantum-potential.com

Abstract

Over a quarter of century have passed since Fleischmann and Pons made their startling announcement that they could achieve nuclear fusion at room temperature. Yet, despite immense scientific and commercial importance of the discovery the 'cold fusion' era never came: replication difficulties polarized scientific community creating a controversy that buried all hope for systematic research.

Consequently, small but determined community of researchers continued their efforts in isolation as both proponents and detractors largely chose to ignore each other's existence. Unfortunately, despite hundreds of publications the reality of low-energy nuclear reactions (LENR) remains elusive: to this date there has not been a single experiment that one could replicate with incontrovertible results. Without such an experiment the LENR field will not gain widespread acceptance that it needs in order to give birth to disruptive technologies of the future.

To address this challenge I propose a simple yet elegant experiment, which, if successful, will firmly establish the reality of LENR by proving the hypothesis that neutrons can be synthesized from protons and electrons in low-voltage discharges. The proposed experiment is structured around unpublished work of Ernest Sternglass, a renowned nuclear physicist who was the first to stumble upon this phenomenon in 1951 at Cornell University while working on his Ph.D. thesis. Sternlass discovered that he could synthesize neutrons via 20-35kV arcs in hydrogen-filled X-ray tubes and communicated his results to Einstein. Einstein recognized the significance of Sternglass' discovery and encouraged him to continue his research and publish the results despite the incredulity of peers. Some 60 years later we heed to Einstein's advice and recreate Sternglass' seminal work. By employing modern instrumentation, stringent controls, and sound data analysis we are hoping to conclusively prove the reality of neutron synthesis in arc discharges discharges and thus put the LENR on firm scientific footing. By designing a simple experiment that is easy to replicate we aim to eliminate the key obstacle in the way of systematic study of the LENR phenomena.

What is LENR?

Broadly speaking low-energy nuclear reactions encompass the purported nuclear phenomena that cannot be easily explained from the standpoint of the 'accepted' nuclear and quantum theories. The alleged phenomena are not confined to the design of the original (Fleischmann and Pons 1989) experiment where palladium electrodes loaded with deuterium apparently produced tritium and excess heat when subjected to electrolysis in an electrochemical cell, but also include element transmutation in plasmas, cavitation, and purported changes in rates of radioactive decay (Mizuno 1998), (E. Storms, A Student's Guide to Cold Fusion 2012), (Storms, Status of Cold Fusion 2010).

The unifying factor of all alleged LENR phenomena is that purported nuclear processes (fusion or fission) occur at energies that are evidently much lower than those required by 'conventional' physics. Because modern physics is regarded is widely successful the purported LENR phenomena is generally viewed as erroneous and – somewhat illogically – not worthy of an investigation despite extreme simplicity, immense practical importance and relatively low cost of experimentation. Yet, despite wide opposition and limited or altogether non-existent funding LENR research is slowly gaining popularity among major U.S. educational, military, and research institutions:

- NASA Glenn Research Center is actively testing electrolytic cells and cavitation of heavy water approaches to LENR (Wrbanek, et al. 2013);
- U.S. Navy (both Naval Research Laboratory, NRL, and Space and Navy Warfare Systems, SPAWAR) are engaged in various aspects of LENR research (Kidwell, et al. 2013) and are successful in obtaining patents (Boss, et al. 2013);
- University of Missouri has organized a Sidney Kimmel Institute for Nuclear Renaissance, SKINR, (Basi 2013) to study LENR phenomena;
- Professor Hagelstein is offering "Cold Fusion 101: Introduction to Excess Power" course at MIT.

And there are at least a dozen private companies working on commercialization of LENR with several claiming commercial products available for purchase or already deployed at for-revenue applications (DeChiaro 2015):

- Industrial Heat (Andrea Rossi);
- Nanortech (Mitchell Swartz);
- Brillouin Energy (Robert Godes)
- etc.

Despite the obvious advances, what makes understanding LENR particularly difficult is the lack of the unifying hypothesis on the nature of this phenomenon. Indeed, without such hypothesis how can one effectively verify the reality of LENR?

Fortunately, recently the hypothesis of (Widom and Larsen 2006) on the synthesis of ultra-low momentum neutrons via inverse beta decay mediated by collective

electron effects (i.e. electron capture by protons) has gained popularity and is approaching the status of such 'unifying hypothesis'. Therefore from the standpoint of scientific method confirming LENR would mean confirming the hypothesis of synthesis of neutrons under *low energy* conditions.

Note that because low-energy neutron synthesis is one of many hypotheses that one can conceive in order to explain LENR refuting it would not necessarily invalidate the LENR proposition: any student of philosophy knows that it is common logical fallacy trying to extrapolate the disproof of existence into the proof of 'non-existence'; for that matter we can never disprove LENR although we can disprove numerous hypothesis aimed at explaining LENR.

The Politics of Discovery

My father-in-law (who also happened to be my Ph.D. thesis advisor) was unquestionably correct by pointing out that only boring research gets the light of day as an excitement in science may be perilous and often provokes opposition.

Although the scientific community welcomes certain exciting ideas that corroborate the established doctrine the ideas that threaten status quo are usually vehemently opposed. Perfect example is the discovery of neutrino in (Cowan and Reines 1956) experiment. (Arns 2001) gives a vivid account on the history of the neutrino problem and derives a crucial conclusion that the neutrino hypothesis was quickly accepted *despite* numerous experimental difficulties, *notwithstanding* the irregularities in data, and *absent* of independent confirmation because the rest of the scientific community badly needed neutrino to prevent a major crisis in nuclear physics. In fact to this date (Cowan and Reines 1956) experiment has not been independently replicated! Yet nobody questions the validity of their results or the reality of neutrino existence.

The same physicists that so readily admitted the neutrino hypothesis stubbornly oppose the hypothesis of low-energy nuclear reactions despite copious evidence and dozens (if not hundreds) of independent experiments. Never mind the fact that neutrinos are essentially 'ghost' particles that interact extremely weakly, they cannot be observed directly and are extremely difficult to detect whereas key LENR phenomena can be easily recreated and observed on one's desk.

The difference in attitude lies in the disruptive nature of the LENR idea, which threatens to undo what neutrino so laboriously helped to establish. We may be in the midst of a paradigm shift that precedes the next scientific revolution, a process brilliantly described by (Khun 1962). Indeed, "science advances one funeral at a time", as shrewdly noted by Max Planck.

So what is so threatening about LENR? From the theoretical point of view, perhaps nothing. Although we do not know whether LENR is compatible with the venerated and quite successful Standard Model of particle physics (Oerter 2006) there are ample suggestions, e.g. by (Widom and Larsen 2006), (Chubb 2005), or (E. Storms 2014) on how to explain the LENR phenomena using the established theories.

What LENR truly threatens to disrupt is the flow of research dollars: because LENR experiments are much simpler and far less costlier than conventional 'hot' fusion, the established fusion projects are likely to receive a dramatic cut in funding or to be altogether shattered should the LENR field prove fruitful. In many ways conventional multi-billion dollar fusion projects (such as National Ignition Facility or Princeton Plasma Physics Lab) have grown an entire ecosystems around them and became 'too big to fail'. Therefore it is only natural that an alternative fusion idea might be perceived as a life threat. Perhaps a better approach to funding fusion would have been to setup an institute tasked with developing cheap, clean energy no matter the source, and technology cost should have been made the key metric in judging the project's progress and promise. Such approach would have made reliance on a particular technology unimportant to the organization's survival and actually would have encouraged exploration of alternative ideas, especially those that come with significant cost savings.

Politics of the organized research aside, the other real issue plaguing LENR research is the generally low quality of published works. Because LENR researchers publish almost exclusively in obscure second or even third-tier journals or forgo the peer-review altogether, the quality of the publications leaves much to be desired. The amazing quantity of published rubbish makes it very difficult even for a willing researcher to extract useful information: e.g. experimental setups are often poorly described or missing critical details, statistical methods are weak, controls are non-existent, and alternative explanations are not thoroughly considered. Clearly the opposition of top-tier journals to publication of LENR research (sometimes by imposing impossible standards, but more often on the grounds of policy, e.g. 'we do not publish articles on LENR') has contributed negatively to the quality of LENR research by eliminating the scientific dialog between the proponents and the opponents. After all it is criticism that hones both theory and experiment. Therefore, what is badly needed is a quality experiment coupled with a quality publication, which answers a single well-defined question but does so conclusively and convincingly. In other words, there can be no question mark in the article title!

Critique of Neutron Synthesis According to Widom and Larsen

The basic idea of (Widom and Larsen 2006) that proton and electron could combine producing a neutron is profoundly simple and could be traced all the way to Rutherford who held a view that neutron was a composite particle, a bound state of proton and electron. Although (Klein 1929) has proved that this naïve model is untenable for electron will escape with 100% certainty the extremely narrow (~fm) potential well of the nucleus, modern weak interaction theory supports the transformation of proton into neutron via inverse beta decay:

$$e^- + p^+ \rightarrow \nu_e + n^0 \qquad (1)$$

From the standpoint of weak interaction the reaction (1) is more rigorously expressed by the following steps involving creation of the negatively-charged intermediary W^--boson:

$$e^- + \nu_e \rightarrow W^- \quad (2)$$

or

$$e^- \rightarrow W^- + \nu_e \quad (3)$$

which ultimately changes positively charged proton into electrically neutral neutron:

$$W^- + p^+ \rightarrow n^0 \quad (4)$$

This seemingly simple reaction is best illustrated with the Feynman diagram – Fig. 1.

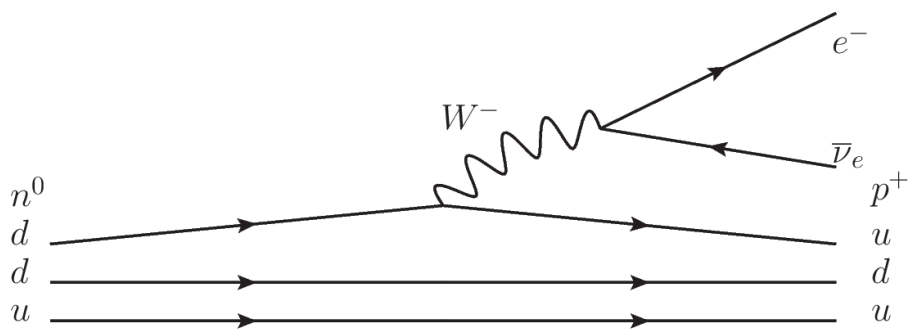

Fig. 1. Inverse beta decay transformation of proton into neutron.

As far as to which reaction (2) or (3) took place quantum mechanics allows us to decide whether a neutrino was emitted or absorbed (if neutrino is not its own anti-particle then we are talking about emission of neutrino and absorption of anti-neutrino). We can decide on the basis of energy balance: it takes $m_n - m_p - m_e$ = (939.6 – 938.3 – 0.51) MeV = 0.79 MeV to make a neutron out of proton and electron. Therefore, when the electron had the requisite kinetic energy of 0.79 MeV or higher we can speak of neutrino emission (carrying off the excess energy). In the case of slow electron the additional energy must have been transferred via neutrino, kind of like in a neutral current interaction when a neutrino transfers its kinetic energy to an electron via neutral Z^0 boson interaction, Fig. 2.

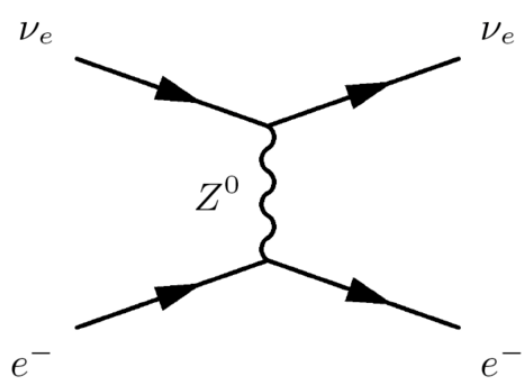

Fig. 2. Neutral current interaction (i.e. elastic scattering) of neutrino and electron.

The neutral current interaction or elastic neutrino scattering has actually been observed experimentally, although probability of such reaction is exceedingly low due to extremely small neutrino reaction cross-sections ($\ll 10^{-52}$ cm^2).

Thus, from the point of view of conventional nuclear physics (which is well-established and supported experimentally) the reactions (1) and (3) are prohibited when the electron's kinetic energy is under 0.79 MeV. However, experimental nuclear physics tells us that even if the electron has energy on the order of MeV it is going to scatter off protons *elastically*, like a Ping-Pong ball, without changing the proton into a neutron. (according to the weak interactions theory at low energies the cross-section for electron capture by proton is on the order of 10^{-42} cm^2).

Generally one needs electrons with much higher energies (>GeV) to cause significant inelastic scattering and the formation neutrons and other subnuclear particles (Friedman and Kendall 1972). Therefore some *new physics* clearly must be at play in order to make the inelastic interaction of protons and electrons *probable* when the law of conservation of energy does not forbid such interaction.

However, it is the law of conservation of energy that forbids neutron synthesis by 'cold' (~keV) electrons. In this regard (Widom and Larsen 2006) argue that the additional energy may come from 'collective electron effects' such as high-energy electron oscillations caused by surface plasmons. Be as it may, (Widom and Larsen 2006) theory still does not explain how the probability of inelastic scattering is dramatically increased at the low energies. That is the key reason why 'mainstream' scientific community rejects (Widom and Larsen 2006) theory (and LENR along with it).

General Neutron Synthesis Hypothesis

Clearly, there is no *known* physical mechanism that could explain neutron synthesis from proton and electrons at low energy. Still the absence of known mechanisms does not rule out the possibility in principle. Unfortunately, it has become a widespread practice by mainstream peer-reviewed journals to reject inconvenient experimental results on the basis of the lack of theoretical explanation or due to their apparent conflict with known theories. One must remember that the objective of science is to establish *observational facts* and then come up with theories explaining the observations and not the other way around where we reject the observations because they do not fit the established theories. Any theory is just a *model* of reality and being a mere model it can never be complete. Thus no matter how successful a theory is, it is destined to be refined and eventually superseded with a better model as our knowledge advances. This statement definitely applies to all theories, including Maxwell electrodynamics, quantum mechanics, or Einstein's relativity. The evolution of scientific theories does not necessarily invalidate prior theories in absolute sense but rather limits the domain of applicability of the prior theory, e.g. Newtonian gravity is perfectly fine for the vast majority of Solar system and even cosmological computations although we must resort to Einstein's general relativity when dealing with extreme mass densities.

So leaving all prejudice aside we shall formulate a general hypothesis as follows: *one can synthesize neutrons from protons and electrons at low energies*. And our specific hypothesis is: *one can synthesize neutrons via an electric arc in H^1 hydrogen gas.*

Neutron Synthesis Experiment by Ernest Sternglass

In 1951 Ernest Sternglass have stumbled upon remarkable discovery at Cornell University while working on his Master's thesis on secondary electron emission. His simple yet elegant experiment demonstrated that one *could synthesize neutrons* via electric arc in X-ray tube filled with hydrogen. Because Sternglass used ordinary hydrogen rather than deuterium his results were completely inexplicable from the standpoint of the accepted nuclear theory and thus baffled the physics faculty at Cornell. The groundbreaking nature of Sternglass' discovery has prompted the eminent Cornell physicist Hans Bethe to call Einstein. Here is the letter that Sternglass wrote to Einstein summarizing his results (reproduced with the permission of the Rare Manuscript Collection division of Cornell University Library):

Ithaca, N.Y.
August 26th, 1951
518 Dryden Rd.

Dear Professor Einstein,

You may be interested to learn that in the course of the past two months I have been able to obtain experimental evidence for the formation of neutrons from protons and electrons in a high-voltage hydrogen discharge.

The experiments were carried out with a demountable gas X-ray tube capable of dissipating 1,200 watts filled with hydrogen and surrounded by about 6 inches of paraffin on all sides. Voltages up to 35 kV and currents up to 40 mA were used and silver and indium foils were placed near the tube walls. The neutron induced beta-activities were measured with a thin-walled aluminum Geiger-Muller counter in a lead housing of about 3-4" thickness giving a background count of 15 counts per minute. The initial activities in indium and silver were found to be 6-7 counts above background, decaying with the respective mean lives of 2.4 min for Ag and 54 min. for In. Having a standard neutron source, this arrangement could be calibrated roughly so that the rate of neutron formation can be determined to be on the order of 10-20 neutrons/sec at 38 mA and 25 kV and an estimated pressure of 10^{-2} mm of mercury in the discharge.

The possibilities of cosmic-ray produced neutrons was eliminated by exposing the foils without turning the discharge on. Contamination of anode & cathode with materials that could give rise to neutrons was eliminated by replacing them with freshly machined parts. The possibility of a deuteron-deuteron reaction was eliminated by a calculation using famous values of the cross-section for this process

leading to a factor of 10^5-10^6 too small a rate of neutron formation by the slight admixture of deuterium in normal hydrogen. So far, no one n the department here has been able to suggest any nuclear reaction that could be made to account for the activity at such a low energy. During the next few weeks we intend to make measurements on the activities in a salt-mine, 2000 ft below ground as to improve the statistics of our counts. Professor Cocconi and Professor Ieiri will setup the equipment for this experiment after which we shall feel ready to announce it possibly at the Chicago meeting.

The indicated rate of formation is consistent with a cross-section of 2.5×10^{-24} cm^2 for the case of an isolated proton capturing an electron in the process calculated by C.G. Darwin in 1913. It is not consistent with the cross-section of 10^{-42} cm^2 predicted by neutrino theory. This seams to lend strongly support to the view that the neutron is a purely electromagnetic entity composed of a proton and a highly "distorted" electron as I have outlined to you in my last letter.

I remain sincerely yours,

Ernest J. Sternglass

Einstein promptly replied noting that Sternglass' setup did not accelerate the electrons to 780 keV necessary for neutron synthesis and suggested that perhaps more than one electron participated in the collective energy transfer that enabled the synthesis. Einstein ended his letter by saying that since the results of the experiments were very important, further pursuit of the method would be necessary.

Not only Einstein clearly recognized the importance of Sternglass' work, he highly encouraged him to "be stubborn" and publish his results (Sternglass 1997). Sadly, Sternglass did not heed to Einstein's advice, he was discouraged by the general attitude of the faculty and instead opted to pursue his research in private. Here is a telling entry from Sternglass' journal:

11/24/51

Talk to Prof. Reisen yesterday made me feel rather upset. He said that even granted that there might be some effect noticeable in my data he would not be interested in it because there have been many queer experiments in the history of physics which no one could explain readily, which no one considered worthwhile spending the effort to analyze. He said that everyone on the faculty feels the same way and that he would have a hard time getting anyone to have anything to do with it, or even to listen to any kind of explanation. He told me that the university can only function of the basis of normal student – teacher relationship and that it simply does not work for me to come and try to teach the faculty. It struck me that this was certainly a strange scientific attitude, and it seams to me that it does not reflect too favorably on the nature of our higher educational system. Fortunately, Prof. Cocconi did not share this

attitude, and after he saw my data yesterday he was sufficiently interested to think that it would be a good idea for me to present my results before the Journal Club three weeks from yesterday.

The experiments that Sternglass began in 1951 showed that neutrons could apparently be formed from protons and electrons at very low energies. He used hydrogen-filled X-ray tube with water-cooled anode and cathode – Fig. 3.

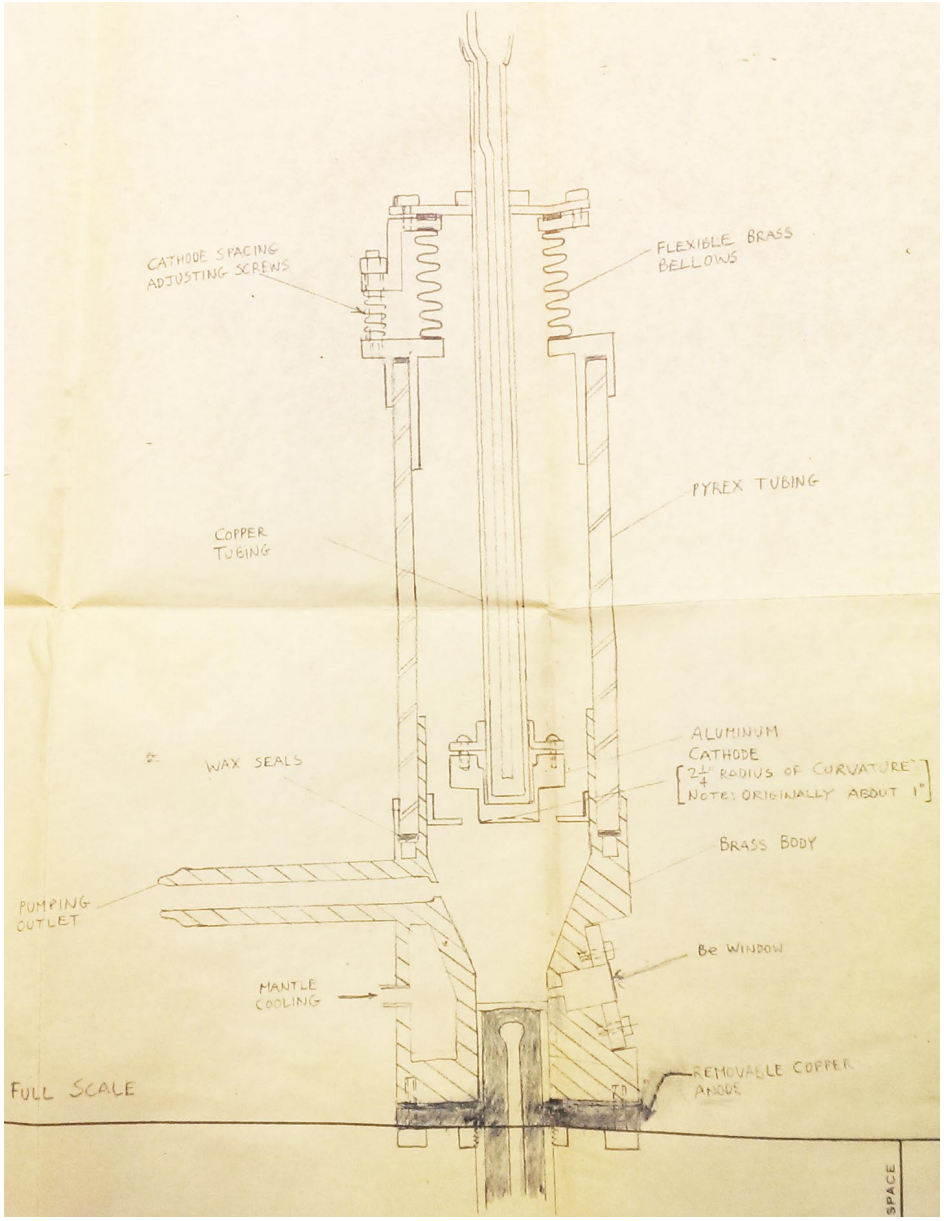

Fig. 3. Sternglass' X-ray tube used in the neutron synthesis experiment.

Apparently motivated by (Darwin 1920), whose calculations indicated that protons might capture electrons at lower energies, Sternglass operated his tube at 20-35kV (instead of few hundred volts necessary for X-ray production), thus increasing the arc current to 20-40 mA.

To detect neutrons Sternglass piled paraffin blocks around silver, indium, and other foils close to the old brass X-ray tube while passing an electrical discharge – Fig. 4. The foil material would absorb neutrons producing activated isotopes that beta-decay producing events (counts) measurable with a Geiger counter.

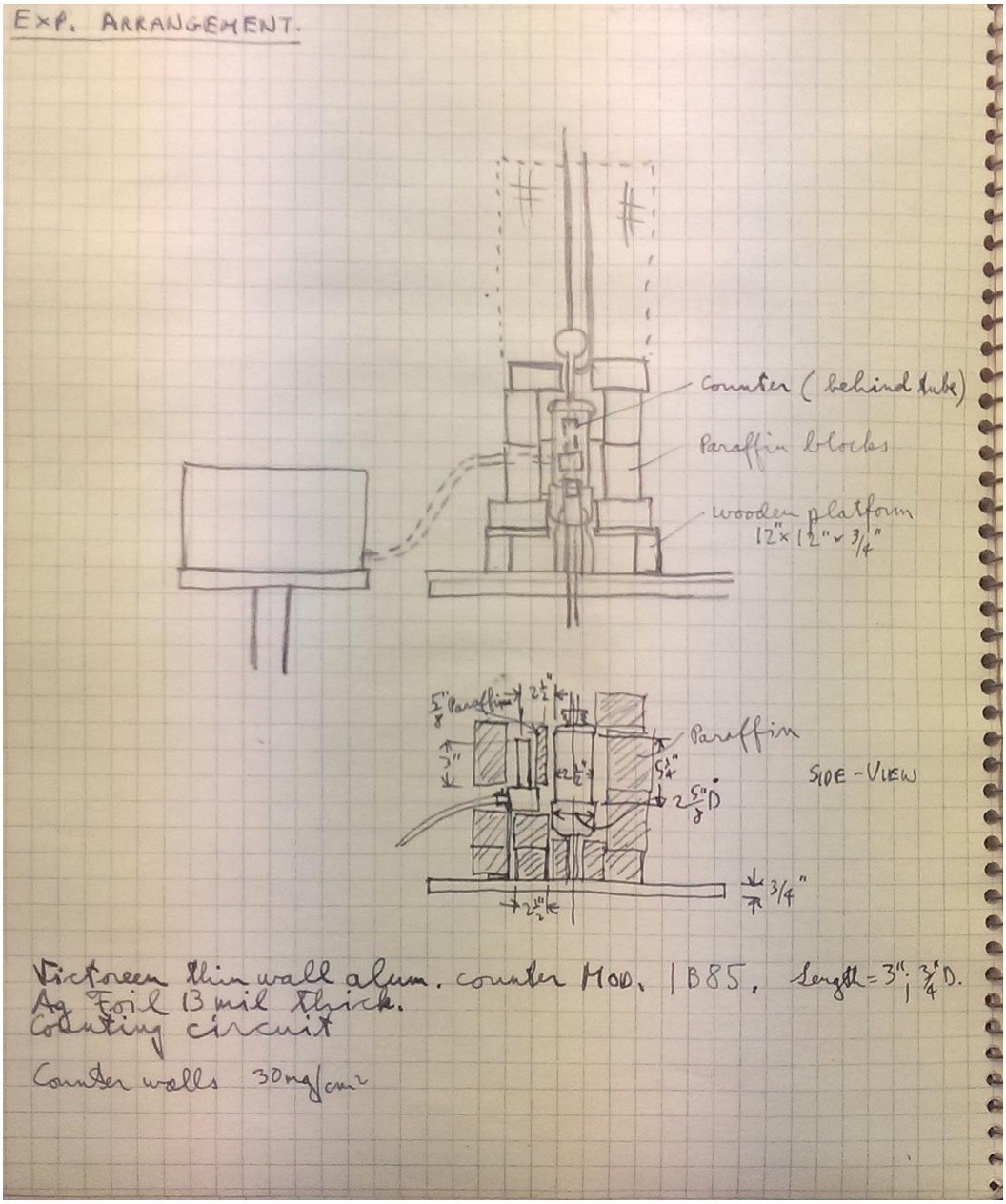

Fig. 4. Sternglass' setup: the X-ray tube surrounded with paraffin blocks.

To everyone's surprise the foils showed signs of radioactivity 30-50% above background – Fig. 5. Sternglass has collected and meticulously documented pages of experimental data. He convincingly ruled out deuterium fusion as a source of neutrons by deliberately adding known amounts of deuterium and measuring change in the neutron production rate: as expected, significant quantities of

deuterium resulted in noticeable increase of counts above background, whereas deuterium quantities below few percent did not register at all (natural abundance of deuterium is only 0.0115%).

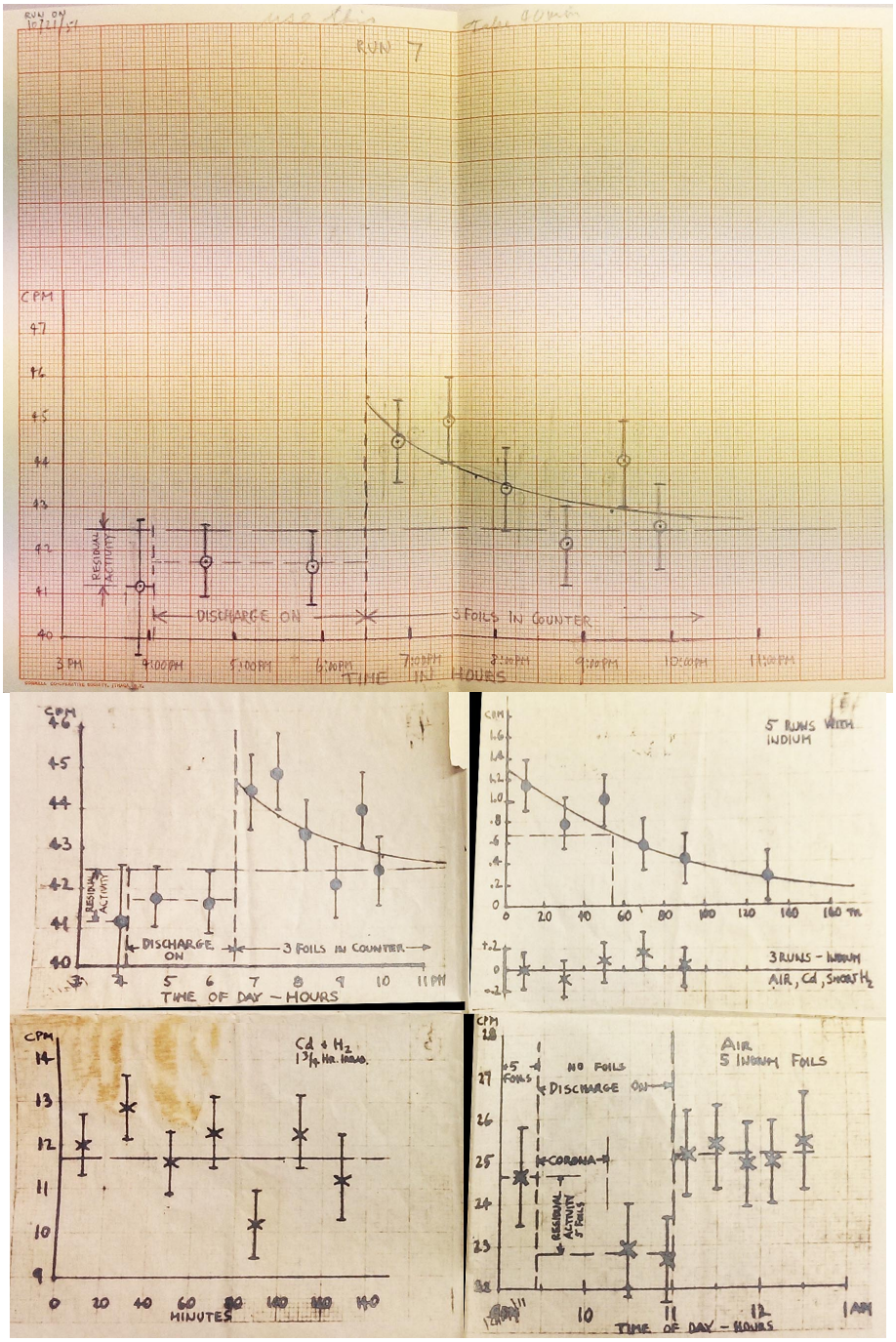

Fig. 5. Sternglass' typical Geiger counts from neutron-activated foils. The foil exposure to the X-ray tube lifts the counts above background (which is shown by a straight line); the exponential decay after the exposure is expected and caused by very short half-life (minutes) of the activated isotopes.

The main focus of Sternglass' work was on increasing the sensitivity of his counters and to improve his counting statistics. E.g. to minimize the influence of cosmic rays Sternglass lowered his exposed indium foils two thousand feet under ground into the nearby salt mine used for cosmic ray experiments, which had much lower background counts, thus improving his signal-to-noise ratio.

Unfortunately, despite the strong results and notwithstanding the encouragement by Einstein, Sternglass had to give up these efforts in order to finish his Ph.D. thesis on secondary emission. Nonetheless, two years later Sternglass' experiment was independent repeated by Edward Trounson, a physicist at the Naval Ordnance Laboratory, with similar results (Sternglass 1997), which unfortunately were not published either except for two-page summary in Sternglass' lab journal.

Some nine years later at the Westinghouse Research Laboratories Sternglass finally resumed this research and carried out an experiment with a separate electron beam interacting with both with solid and gaseous targets in the form suggested by Einstein. No neutrons were produced in this configuration corroborating the hypothesis that 'collective electron effects' must be responsible for neutron synthesis in an arc. Recall that (Rutherford 1922) too did not observe any nuclear transmutations when he bombarded tungsten targets with 100 keV electrons whereas (Wendt and Irion 1922) were able to synthesize helium by way of an arc through tungsten plasma.

Known Replication Efforts

Besides the unpublished replication by Edward Trounson in 1953 at least two other successful replications are known. In 1969 Carlo Borghi apparently was able to synthesize neutrons via arc in hydrogen gas (Borghi, Giori and Dall'olio 1993). Then in 2006 Ruggero Santilli came up with his own version of the experiment where he used commercial welders to produce high-current arc in high-pressure hydrogen (Santilli 2006). Both papers were published in obscure venues and therefore did not register with the scientific community at large.

New Replication of Sternglass' Experiment

We propose to replicate Sternglass' seminal work on neutron synthesis according to the block diagram shown on Fig. 6. The lead-lined (to screen X-rays) water-cooled discharge chamber is connected to vacuum pump and to 99.9% pure hydrogen gas supply bottle for charging the chamber after evacuation with a desired amount of hydrogen. The discharge chamber is connected to high-voltage (1-60kV) X-ray power supply with controllable voltage and current. A neutron detector (preferable He^3) with gamma rejection is placed adjacent to the discharge chamber. For higher efficiency detection the exterior of the discharge chamber can be lined with several neutron detector tubes for 360-degree coverage. In this setup the detection of neutrons that is statistically significantly above background will indicate neutron synthesis.

One control experiment shall include nitrogen in place of hydrogen and should result in no above-background signal on the neutron counter.

Another control experiment shall include plotting of counts vs. deuterium content in the deuterium+hydrogen mixture.

One control measurement shall include using CR-39 plastic detectors on the exterior surface of the discharge chamber, exposing, etching them and examining the tracks via 3rd party service (e.g. Landauer).

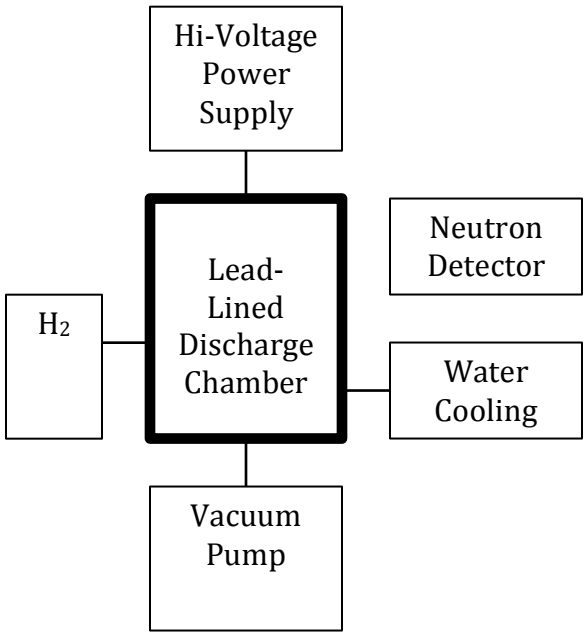

Fig. 6. Neutron synthesis experiment block diagram.

The cross-section of the discharge chamber is given on Fig. 7. Both the anode and the cathode are water-cooled and thread-mounted to regulate the anode-cathode distance. The cathode should have a curvature to it for arc focusing on the anode. The top and bottom plate of the chamber as well as the chamber itself should be manufactured out of dielectric material such as Teflon, quartz glass (no Pyrex!), or PVC. Versions of the chamber can be made for both low (microns of mercury) and high (several atmospheres) pressure. The discharge chamber should be surrounded with lead shielding to screen X-rays generated by the discharge.

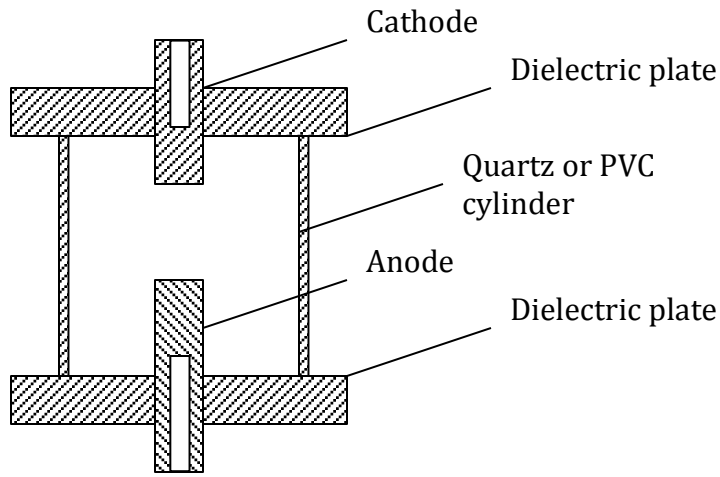

Fig. 7. The cross-section of the discharge chamber.

Significance

The conclusive proof of synthesis of neutrons from H^1 hydrogen will have significant implications for both theoretical and applied nuclear sciences and will be nothing short of revolutionary. Rather than rendering the existing nuclear model completely invalid it will open up a new chapter that will account for low energy nuclear reactions. The firm scientific footing and reproducibility warranted by the proposed experiment will enable the flow of research dollars into the new means of power generation that are significantly safer and cheaper than conventional nuclear engineering.

Specific immediate applications include power generation (both heat and electric), nuclear battery applications, and nuclear waste remediation. E.g. the development of the low-energy neutron source will make possible power generation from neutron capture by boron. It will also make possible a new kind of nuclear battery where electric power is generated on demand via synthesis of short-leaved beta-emitters with energy captured via conventional beta-voltaic or direct conversion techniques.

Bibliography

Arns, Robert. "Detecting Neutrino." *Physics in Perspective* 3 (2001): 314-334.

Basi, Christian. *Hubler Named Director of Nuclear Renaissance Institute at MU.* March 8, 2013. http://research.missouri.edu/news/story.php?331 (accessed 2015).

Boss, Pamela A., Frank E. Gordon, Stanislaw Szipak, and Lawrence Forsley. System and method for generating particles. Patent US 8419919 B1. April 16, 2013.

Chadwick, J., and M. Goldhaber. "A Nuclear Photoeffect: Disintegration of the Diplon by γ Rays." *Nature* 134 (1934): 237.

Chubb, Scott. "Framework for Understanding LENR Processes, Using Ordinary Condensed Matter Physics ." *APS March Meeting.* American Physical Society, 2005.

Cowan, C. L., and F., et al. Reines. "Detection of the Free Neutrino: A Confirmation." *Science* 124, no. 3212 (1956): 103-104.

Fleischmann, Martin, and Stanley Pons. "Electrochemically induced nuclear fusion of deuterium." *Journal of Electroanalytical Chemistry* 261, no. 2A (1989): 301-308.

Khun, Thomas. *The Structure of Scientific Revolutions.* University of Chicago Press,, 1962.

Kidwell, D. A., et al. "Low Energy Nuclear Reaction Investigations at the Naval Research Laboratory." *18th International Conference on Condensed Matter Nuclear Science.* Columbia, Missouri, 2013.

Klein, O. "Die Reflexion von Elektronen an einem Potentialsprung nach der relativistischen Dynamik von Dirac." *Zeitschrift für Physik* 53, no. 3-4 (1929): 157.

Mizuno, Tadahiko. *Nuclear Transmutation: The Reality of Cold Fusion.* Cold Fusion Technology, 1998.

Oerter, Robert. *The Theory of Almost Everything: The Standard Model, the Unsung Triumph of Modern Physics.* Plume, 2006.

Storms, Edmund. *A Student's Guide to Cold Fusion.* April 2012. http://lenr-canr.org/acrobat/StormsEastudentsg.pdf (accessed 2015).

Storms, Edmund. "Status of Cold-Fusion." *Naturwissenschaften* 97 (2010): 861.

—. *The Explanation of Low Energy Nuclear Reaction: An Examination of the Relationship Between Observation and Explanation.* Infinite Energy Press, 2014.

Widom, A., and L. Larsen. "Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces." *The European Physical Journal C* 46, no. 1 (April 2006): 107-111.

Wrbanek, Susan Y., Gustave C. Fralick, John D. Wrbanek, and Janis M. Niedra. *NASA Glenn Research Center experience with "LENR Phenomenon".* 2013. http://www.grc.nasa.gov/WWW/sensors/PhySen/docs/IPAG12_Presentation.pdf.

View publication stats