21st International Conference on Condensed Matter Nuclear Science

Abstracts

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Cold fusion: superfluidity of deuterons.

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The nature of cold fusion (CF) is considered. It is supposed that the reaction of deuterons merger takes place due to one deuteron, participating in the superfluidity motion, and one deuterons, not participating in the superfluidity motion, participate in the reaction. The Coulomb barrier is overcomed due to the kinetic energy of the Bose-condensate motion is very large. The Bose-condensate forms from delocalized deuterons with taking into account that the effective mass of delocalized deuterons is smaller than the free deuterons mass.

The effective mass of deuterons must satisfy the condition

$$m^* < 1.5 \frac{\hbar^2}{kT_0} n^{2/3} \ , \qquad (1)$$

where n is the concentration of the delocalized deuterons, T_0 is the temperature of the Bose-condensate. Using the values $T_0 = 300\ K$, $n = 10^{22} sm^{-3}$, obtain the estimation

$$m^* < 2 \cdot 10^{-26} g \approx 0.006\, m_d \qquad (2)$$

The Bose-condensate moves in the magnetic field with the speed v_{si}**,** defined by ratio

$$en_s v_{si}(\mathbf{r}) = - \int Q_{ik}(\mathbf{r} - \mathbf{r}')A_k(\mathbf{r}')d^3r', \qquad (3)$$

where n_s is the concentration of particles of the Bose-condensate, $A_k(\boldsymbol{r})$ is the vector potential of the electromagnetic field. The function $Q_{ik}\,(\boldsymbol{r})$ is defined from microscopic analyze of the motion of the Bose-condensate. The motion of the Bose-condensate is considered in the framework of the London's electrodynamics. This approximation allows obtain the linear on the field term in the expression for the power, exuding in the reaction. Exuding in the cylindrical form sample power is equal to

$$W = 2\pi r_d^2 \frac{B_0 c}{e} h r_0 P_0 n_d E_0 \qquad (4)$$

Here r_d –the deuteron radius, B_0 – the value of vector $\boldsymbol{B}$ of the external magnetic field, c –the speed of light, e- the electron charge, h -the high of the cylinder, r_0 –the square of the bottom of the cylinder, P_0 – the probability of reaction with collision of two deuterons, n_d – the concentration of deuterons in the lattice, E_0 – output of the energy in one nuclear reaction.

We obtaine the estimation $W \sim 10^9\ erg/s$ for the sample with $h = 10\ sm$, $r_0 = 1\ sm$, in the field $B_0 \approx 0.5\ Gs$ under $n_d \sim 10^{23}$ см$^{-3}$, $P_0 \sim 10^{-5}$. This estimation is coincided with the experimental data [1] by the order.

It can be understood why mainly occur the reactions

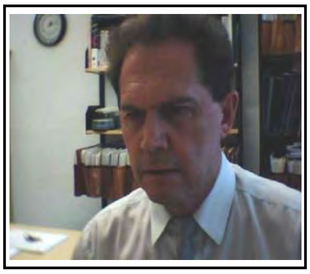
$$B_d + d + d \rightarrow\ ^4He + B'_d + 23.8\ \mathrm{MeV}$$

Here B_d and B'_d are the states of the Bose-condensate before and after the collision of one deuteron, belonging to the Bose-condensate, and one deuteron, not belonging to the Bose-condensate. Gamma-quantum does not stand out in the reaction (5) due to the large amount of particles of the Bose-condensate change their velocities. The momentum and the energy under the reaction condition conserve due to this fact.

It can be understood why the CF-reactions occur in palladium and titanium only. This fact is connected with the effective masses of delocalized deuterons in palladium and titanium are small.

[1] E.Storms "Status of cold fusion (2010)", Naturwissenschaften, vol. 97,no. 10, pp. 861-881, 2010.

Nuclear fusion in solids – experiments and theory



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Experiments about low temperature nuclear fusion in several metals (including Pd) have been performed and new theory providing explanation of the observed results has been developed. The results are presented in this paper.
The experiments were performed in vacuum chamber in order precise measurements to be achieved and due to the relatively low concentrations of the interacting gases the amounts of the generated helium and of the generated energy (heat) were relatively low. In fact D_2 gas in environment of H/H_2 gas in the chamber was directed to metal sample placed on sample holder and generation of both ^3He and ^4He was observed in all experiments as it was supported by the following facts: *i)* Mass analysis shows relatively high amount of ^3He; *ii)* Mass analysis shows relatively high amount of $^4He/D_2$ and relatively significant amount of ^4HeH that confirms relatively high amount of ^4He; and *iii)* DC plasma spectroscopy shows peaks typical for both ^3He and ^4He. The experiments were carried out in two modes – without plasma and with plasma containing both deuterium and hydrogen ions. In the second mode the kinetic energies of both D and H ions were determined and it was found that the amounts of both ^3He and ^4He increase with increase of these energies. It was found that the pressures of both ^3He and ^4He increase with increase of the deuterium pressure. (Graphics of ^3He vs. D_2 for both plasma mode and no-plasma mode are provided in Fig.1.) The temperature of the sample holder was measured during the experiments and cyclic dependence on the time was found (Fig.2) and also it was fond that this dependence correlates with changes in the amounts of both ^3He and ^4He in the time. In some experiments external heating of the sample holder was performed in range 100^0C-700^0C and it was found increase of the amounts of both ^3He and ^4He with increase of the temperature. Radiation (including gamma rays and neutrons) was measured in all experiments and no increase of the radiation above the normal background was found. (Absence of increase of the radiation is due to either: *a)* The low amounts of gases used in all experiments gives a radiation, which is very small and cannot be detected by the used devices; or *b)* These is no radiation at all due to the low kinetic energies of the interacting D and H nucleus in solids.)
The experimental results provided above are explained with new developed quantum mechanical theory based on interaction of both D and H nucleus with heavy electrons that are localized in solids. The theoretical outcomes are consistent with the above experimental results and they provide proof that two nuclear fusion schemes in solids have places: *i)* $D+H \rightarrow {}^3He$+energy; and *ii)* $D+D \rightarrow {}^4He$+energy. Also the theory explains increase of the amounts of both ^3He and ^4He with increase of the temperature of the sample and with increase of the kinetic energies of both D and H nucleus. The theory is valid for all solids, however it determines that the above nuclear fusion reactions can have places only in solids having certain properties. (Pd metal is one of these solids.)

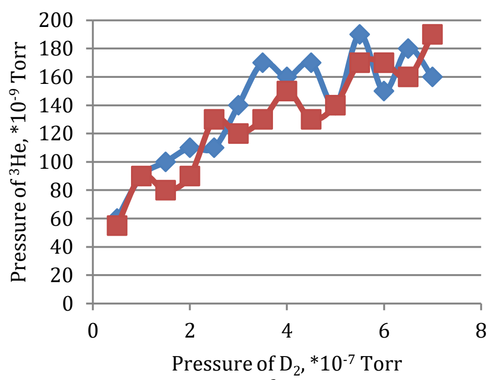

Fig.1: ^3He vs. D_2

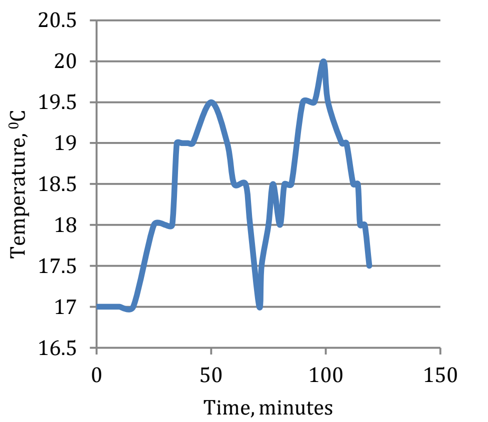

Fig.2: Temperaure vs. time

Warp Drive Hydro Model
For Interactions Between Hydrogen and Nickel

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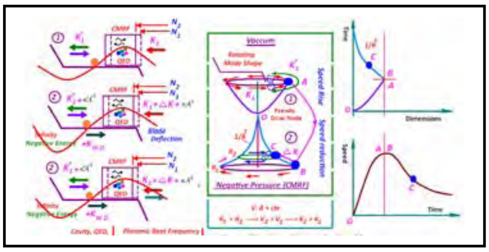
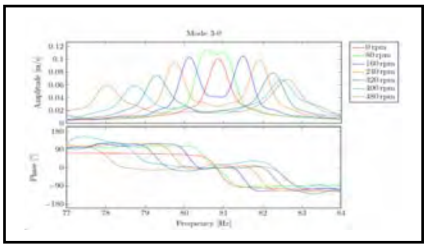
The Model of Warp Drive Hydro (WDH) Turbine have been applied to study about the interaction between hydrogen and crystal lattice of nickel. WDH is used for the required propulsion in order to the motion of plasma particles and hydrogen atoms inside the specific medium. The effects of infinity can be studied in hyperbolic model. A Weierstrass model has been implemented on the specific runner (disc model) of rotary machine. The jet plasma implanted on the blade can behave like infinitesimal size particles in the crystal lattice of nickel metal. The pre-twisted blade is placed in the geometric model and affects on the torque fluctuation of blade and generation of shear stress ,contraction and expansion for the parts of blade surface during passing rotating mode shape. The beat acoustic frequency caused by rotating mode shape on the runner act as an anharmonic force on the crystal lattice of blade[1]. The negative energy inside the crystal lattices and motion of mode shape generate a virtual warp drive for the motion of plasma bunch. Such warp drive goes through the conduit between two adjacent lattices at ZPE and or CMRF at vacuum mediums. The pairing process between protons and electrons can occur inside the thermo-acoustic. The acoustic wave can help to quantize the particles energy. If this phenomena occur in this acoustic wave, the cold particles will be placed in the low level. QED and Rydberg state of hydrogen atom and as well the collapse of bubbles generate the photons and luminescence. The beat photonic wave and the similar CMRF on the crystal lattice caused by stress on the SPR wave on the nickel and CMRF play a significant role in the main process. The charge's current density isn't zero at anharmonic wave and infinity. The cooling process can occur at helical spinning cone on the trailing edge and infinity, thus it is expected to make the specific condition. The capillary effect behaves as a tunnel at vacuum field under rotation. The speed rise and the motion of particles inside the tunnel can make the Coriolis effect. The Coriolis effect can form swirling while particle move towards the center of circle down in the low pressure zone and swirling motion can decrease temperature of particles and to cool them. Also, it generates the electromagnetic field and Z-pinch.

Rotating mode shape of runner and the spinning helical cone of trailing edge act like the standing wave[1]. The energy of infinitesimal particles as ether is stored in the standing wave of harmonic waves. Tractric path of spinning helical cone of trailing edge can generate the anharmony wave on the blade. Warp Drive can increase the velocity and Z-pinch of bunch plasma. The squeeze film levitation in the subspace caused by shear stress are influenced by the harmonic waves.The new instantaneous bonding between particles can make the new virtual atoms along with their reserved energy. In this case, there is possibility for the energy released by the contraction of the virtual atoms.





[1]P. Schmiechen, "Travelling Wave Speed Coincidence", Imperial College of Science, Technology and Medicine, University of London, May 1997.

The SAFIRE Project – An overview

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The SAFIRE project seeks to test the hypothesis of an electrically powered sun. This talk will give an overview and history of the electric sun model in comparison to the standard thermonuclear, gravity driven model. The underlying concept of the electric sun, electric charge affecting matter at a different electrical potential, will be discussed in relation to the SAFIRE instrumental design. Recent experiments and results will be shared. In particular, stable electric double layers about a spherical anode were produced in a consistent and replicated manner, as well as other plasma features such as anode tufts (Figure 1). The electric double layers radiate in the IR, visible, and UV spectrum as striations. Optical spectroscopy and variations in plasma potentials of the striations are consistent with local electron temperatures of 80,000°K and stably maintained free electron variations comparable to those seen between low layers of solar atmospheres. Data from a floating electric probe revealed multiple deep potential wells and nearly a 10 fold increase in electric potential within 1-2mm of a stainless steel anode (going from ~30V to ~350V). Such findings are consistent with the perplexing temperature gradient of the sun, which rises from ~5000°K at the chromosphere and photosphere and then rapidly ascends to ~1,000,000°K moving outward into the corona. Further experimental plans to test for transmutation on the anode surface and within the double layers will be presented along with proposed nuclear reactions.

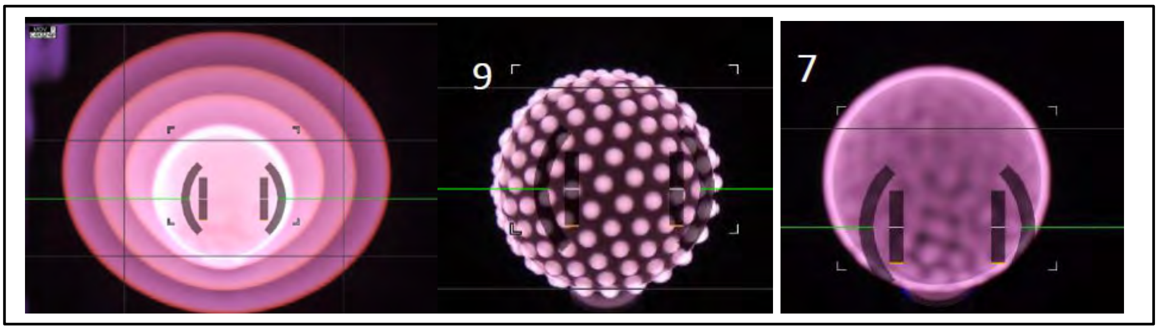

Figure 1. Various screen captures of the spherical anode from different experimental conditions in the SAFIRE apparatus.

Flow Calorimetry Design for Elevated Temperature Experiments with Deuterium and PdZr Nanoparticles

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Abstract

Results from pressurization of chemically reactive nanoparticle metal hydrides with hydrogen gas have shown consistent behavior of a net anomalous heat. With consultation from peers, and from encouraging data, there has been an effort to analyze these experiments with deuterium gas at higher temperatures. The calorimetry for higher temperature experiments is complicated by normal means; therefore, a high temperature calorimetry setup was designed to allow for proper heat transfer measurements of the system. This setup consists of a flow of water around the reactor to which the reaction heat transfers. The change in the water temperature from inlet to outlet can be integrated over time to to calculate the total heat released from the reaction. This paper discusses the design of this system and the results that followed.

Investigation of the Nickel-Hydrogen Anomalous Heat Effect

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Experimental work was undertaken at The Aerospace Corporation to reproduce a specific observation of the gas-phase Anomalous Heat Effect (aka LENR).[1] This task required the production of a quantity of heat energy by a mass of material so small that the origin of the energy cannot be attributable to a chemical process. The goal is to enhance its credibility by reproducing results first demonstrated in Japan and later reproduced in the U.S. by a solitary investigator. The technique heated nanometer-sized Ni:Pd particles (20:1 molar ratio) embedded in micron-sized particles of an inert refractory of ZrO_2. It was not within the purview of this work to investigate the physical origin of the AHE effect or speculate on its source.

An apparatus was built that comprised identical test and a reference heated cells. These thermally isolated cells each contained two thermocouples and a 10 cm^3 volume of ZrO_2NiPd particles. Calibration functions to infer thermal power from temperature were created by electrically heating the filled cells with known powers when they were either evacuated or pressurized with 1 bar of N_2. During the experimental trial, the test cell was pressurized with hydrogen and the control cell was pressurized with nitrogen. After conditioning the cells, both were heated to near 300°C for a period of 1000 hours (40 days). During this period, the test cell registered 7.5% more power (approximately 1 W) than the input power. The control cell measured approximately 0.05 W of excess power. The error in the excess power measurement was ±0.05 W.

Time-integrating the excess power to obtain an excess energy and normalizing to the 20 gram mass of the ZrO_2NiPd sample yields a specific energy of 173 MJ/kg. Assuming that the active material is the 5.44g of Ni+Pd yields a specific energy of 635 MJ/kg. For comparison, the highest specific energy of a hydrocarbon fuel (methane) is 55.5 MJ/kg. The highest chemical specific energy listed [see Energy Density in Wikipedia] is 142 MJ/kg for hydrogen compressed to 700 bar. Based on these results, it is unlikely that the source of heat energy was chemical in origin.

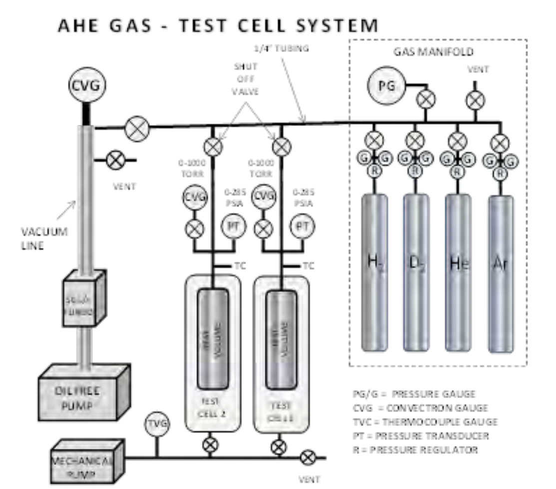

Figure 1. The gas cell system

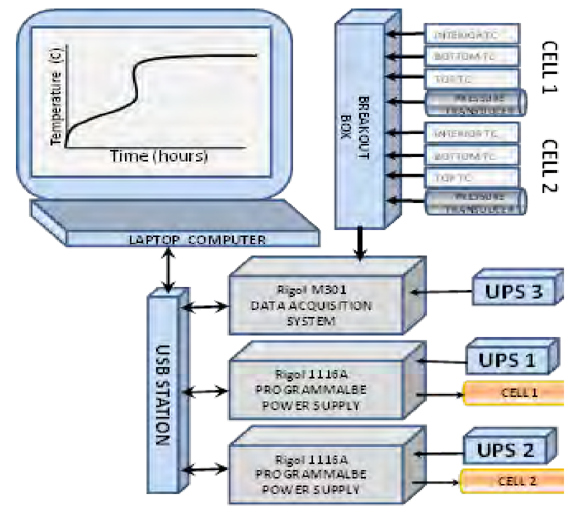

Figure 2. The data acquisition system.

[1] E. Beiting, "Investigation of the nickel-hydrogen anomalous heat effect," Aerospace Report No. ATR-2017-01760, The Aerospace Corporation, El Segundo CA, USA, May 15, 2017.

Generation of High-Temperature Samples and Calorimetric Measurement of Thermal Power for the Study of Ni/H_2 Exothermic Reactions

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Instrumentation developed to measure heat power from a high-temperature reactor for experimental trials lasting several weeks is being applied to gas-phase Ni/H_2 LENR. We developed a reactor that can maintain and record temperatures in excess of 1200^o C while monitoring pressures exceeding 7 bar. This reactor is inserted into a flowing-fluid calorimeter that allows both temperature rise and flow rate of the cooling fluid to be redundantly measured by different physical principles. A computerized data acquisition system was written to automate the collection of more than 20 physical parameters with simultaneous numerical and dual graphical displays comprising both a strip chart and complete history of key parameters.

The water inlet and outlet temperatures of the calorimeter are simultaneously measured with thermocouple, RTD, and thermistor sensors. The water flow is passed in series through two calorimeters and a Hall-effect flow meter. The first calorimeter houses a resistance heater of known input power, which allows the flow rate to be inferred from the heater power and water inlet and outlet temperature difference. Careful calibration of this system produces a nominal accuracy and precision of ±1 W.

The reactor is constructed by tightly wrapping Kanthal wire around an alumina tube, which is embedded in ceramic-fiber insulation (see Figures 1 and 2). The length of the alumina tube is chosen so that its unheated end remains below 100^o C when the interior volume of the heated end is 1300^o C. During use the internal reactor temperature is inferred from two type-N thermocouples fixed to the outside of the reactor using a previously made calibration that employed internal thermocouples. Using external thermocouples have advantages: the thermocouple metals cannot react with the reactants; the thermocouples are kept at lower temperatures (usually < 1000^{o}C) increasing the thermocouple's life and accuracy; no high pressure/vacuum feedthrough is required; no high temperature electrical insulation isolating the thermocouple from the reactants is necessary.

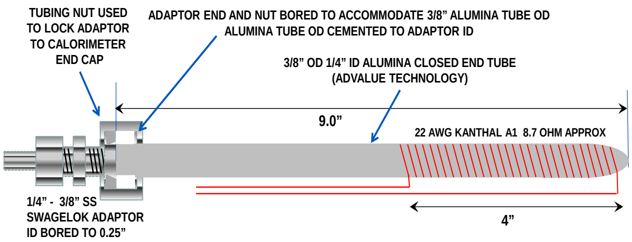

Figure 1. Reactor Design

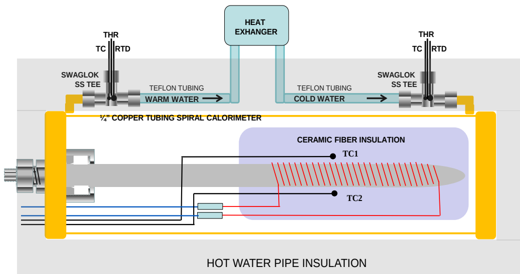

Figure 2. Reactor inside the calorimeter.

This instrumentation is being used to study the gas-phase anomalous heat effect (aka LENR) using nickel and light hydrogen. Tests are being undertaken using both $LiAlH_4$ and bottled H_2 as the source of hydrogen. The results from these tests will be presented with special emphasis on the morphology and the cleaning of the surface of the nickel particles, absorption of hydrogen by the nickel, and excess heat or lack thereof.

All techniques and data will be presented in sufficient detail to allow reproducibility. Nothing will be deemed proprietary. Source code and documentation of the data acquisition software resulting from a significant development effort will be distributed on request.

Study of a Calorimetry Apparatus utilizing Radiation based Heat Transfer

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Abstract

The paper will discuss a radiation based heat transfer approach of a calorimetry device. In this study, the calorimeter was placed in a vacuum to mitigate heat transfer via conduction/convection to the environment. This radiation-only calorimetry devices was used to investigate metal hydride formations and to compare the expected thermodynamic output to actual results. The design, instrumentation and calculation methods of this device will be discussed. As a complementary study, COMSOL Multiphysics® models were used to investigate accuracy of the system. Results from this COMSOL comparison will also be presented.

Anomalous Isotopic Composition of Silver in a Palladium Electrode

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In 2001, Stanley Pons gave me a palladium cathode that had produced a lot of excess heat. The electrode was 10cm long and 2mm in diameter. It was pure palladium and was used in an ICARUS 9 calorimeter. The electrode stayed in my drawer for years, until I found a laboratory that could do dynamic SIMS (Secondary Ion Mass Spectroscopy). The equipment was a Cameca 4f machine that can detect masses of elements with high sensitivity.

The analysis showed the presence of silver at the surface of the cathode, but not in the bulk. Silver was not spread uniformly on the cathode, but there were hot spots with silver. The SIMS machine used an oxygen ion beam for sputtering the surface. A thin film of 100nm of palladium on silicon permitted the calibration of the etch rate.

We show that at hot spots, the ratio between Ag-107/Ag-109 is close to 10, whereas in natural silver this ratio is 1.06. A depth profile analysis shows that silver disappears at one micron of the surface.

This work shows first, that in addition to the production of helium-4, there is also transmutation of palladium to silver. Also, this analysis shows that cold fusion reactions occurs at a maximum depth of one micron.

Understanding LENR Using QST

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Quantum Spring Theory (QST) is a paradigm shift in physics stemming from the observation that we know a lot more today than was known 100 years ago when first attempting to explain the unexpected behaviours observed at subatomic scale. At the time the conclusion was that normal physics did not apply at subatomic scale. QST maintains that normal physics does apply at subatomic scale; it is space that has properties but which are only observable at that scale. In particular the effect of creating a particle places stress on the surrounding space, a concept explored initially in [1].

If correct, the importance of the realization that classical physics applies at subatomic scale cannot be underestimated. It removes the need for a theory of nuclear interaction which is independent of the rest of physics, laying the foundation for a unification of physics not previously possible. Suddenly a whole raft of previously mysterious phenomena are revealed as sensible consequences of classical physics. We present some of the more recent, previously unpublished results of the QST model in a companion paper at ICCF-21.

In this paper we discuss the extent to which QST does—and does not—explain the many diverse experimental results observed in the pursuit of LENR. In a soon to be published paper, David Nagel challenges theoretical models of LENR to explain a set of experimental observations and consequent questions which any good theory of LENR should be able to answer [2]. The experimental results have all been observed and published on multiple occasions, and the questions posed are directed at uncovering the ability of any given theory of LENR to assist in producing more stable and reliable LENR experiments, hopefully leading eventually to commercial application and freedom from the burden of fossil fuels.

The cited paper provides a fortuitous framework for assessing the ability of QST to assist in the creation of a practical LENR solution. As QST places the LENR phenomenon on a classical physics foundation, it becomes clear there are only a few basic conditions that must be present for LENR to occur:

1. A physically *stable target nucleus* experiencing minimal phonon motion.

2. An *impact nucleus with sufficient speed* (i.e. energy) to overcome the opposing Coulomb forces.

3. A *trajectory*, possibly guided by the lattice, encouraging the impact nucleus to collide with the target.

Nearly all of the observed experimental phenomena can be understood in terms of aiding or impeding one or more of these conditions. Many of the experimental conditions might promote one of these at the expense of the another, nonetheless enhacing the overall conditions amenable to LENR.

This paper is not a defence of QST; instead, its current shortcomings are exposed. These may be due to inadequacies in the theory, but we see them more likely as the result of limited resources devoted thus far to resolving the remaining issues. This creates an important opportunity to make new contributions to both QST and LENR.

Even if some aspects of QST should prove useful in understanding LENR, this would not imply that other theories of LENR are somehow incorrect. Theories have a scope: a set of physical phenomena they explain and predict. Multiple theories can have overlapping scope. Furthermore, QST has the defect that its rather peculiar fundamental axioms must be embraced in order to confidently leverage its conclusions. These axioms are new and to some degree still unsubstantiated, relying on logic and circumstantial evidence to support the claims. In the face of these difficulties, other theories may be superior in explaining aspects of LENR until QST can mature to its full utility.

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[1] Blake, R., "The effect of particle creation on space", *J. Phys.: Conf. Ser.* **222,** No 1, 012043, 2010.
[2] Nagel, D., "Expectations of LENR Theories", JCMNS, to be published.

Further Foundations of Fusion

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Since the discovery cold fusion in 1989, no theoretical model has been able to fully account for the observed phenomena. This is in part because, although nuclear binding energy is the best measured property of fusion, no previous model of the nucleus has accurately explained the experimental data for small nuclei. Current models either get the general shape of the curve right but the magnitudes wrong, or get closer to the magnitudes but deviate from the shape of the curve [1].

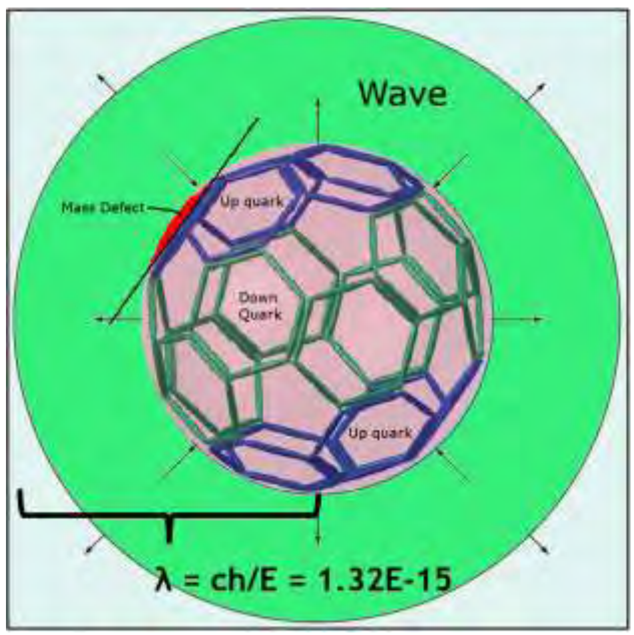
Previously we introduced a model of nuclear fusion free of these defects [2]. Average absolute difference between the model and experimental data is 1.43%, a significant improvement over previous models.

Table 1. Accuracy of models of binding energy

Model	Average Absolute Error	Correlation Coefficient
Quantum Spring Theory	1.430%	0.99893
Face-Centered Cubic	10.950%	0.91500
Liquid Drop	55.918%	0.98057

This excellent fit of theory to experimental data is the result of plausible models of protons and neutrons deduced from their known properties, which lead to a simple physical interpretation of the mass defect, or binding energy, of fusion.

These particle models of protons and neutrons combine with electromagnetic forces to duplicate the binding energy of 12 isotopes from deuterium through carbon with correlation 0.99893. In this paper we summarize previous results, then present some new evidence that the model is plausible. We include for the first time images of the models of isotope nuclei from Deuterium through Carbon which yield these results.



Our new findings show how the wave-particle duality explains well-established data on the so-called “nuclear skin” [1]. The figure (right) shows the proton model in the centre surrounded by the first nuclear quantum level of compressed space which has radius equal to the wavelength of the proton, identical to the long-established measurement of the nuclear skin. The red spherical cap, which is lost when the proton butts up against another proton or a neutron, is the mass defect. We introduce additional new evidence supporting the model, derived from examining diffraction at a single edge, the relationship between the nuclear and electron quantum levels, and the increase in mass when approaching the speed of light in a vacuum.

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[1] Cook, N.D., *Models of the Atomic Nucleus*, Springer, The Netherlands, 2006.
[2] Blake, R., “The architecture of nuclear binding energy”, Physics Procedia, Volume 22, pp. 40-55, 2011.

A Simple Calculation of the Inter-Nucleon Up-to-Down Quark Bond and its Implications for Nuclear Binding

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This paper describes an interesting and potentially significant phenomenon regarding the properties of up and down quarks within the nucleus, and how the possible inter-nucleon bonding of these quarks relates to the bonding energy of the nuclear force. A very simple calculation is used, which involves a bond between two inter-nucleon up and down quarks. This simple calculation does not depend on the type or mechanism for the bond; furthermore, this simple calculation does not specify the shape or structure for the nucleus. This calculation only examines the energy of all possible up-to-down inter-nucleon bonds that may be formed within a quantum nucleus.

A comparison of this energy is made to the experimental binding energy with excellent duplication of experimental results, using only one parameter (instead of five, as in the semi-empirical formula). The binding energies are calculated for a representative sample of stable nuclides, going up to uranium U-238. The resulting errors of this calculation are on the order of a few percent (the average error from A=12 to A=50 is 1.68%.)

The potential significance of this finding is briefly discussed. A possible implication of these results is that some significant part of the nucleon-to-nucleon force is not only the residual chromo-dynamic force, but the electromagnetic force as well. The excellent reproduction of experimental data strongly suggests that the inter-nuclear up-to-down quark bonding is a concept that should be more thoroughly examined, and this result should not be relegated as being simply a coincidence.

LENR Catalyst Identification Model

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Many Low Energy Nuclear Reaction (LENR) processes are now well known and well documented. LENR processes typically involve the use of specific catalysts to achieve transmutation and/or excess heat. Models previously proposed to explain LENR processes (Widom Larsen, hadrionic, hydronion, shrunken H, etc.) provide many insights into LENR processes, but do not yet provide a theoretical method for identifying catalysts.

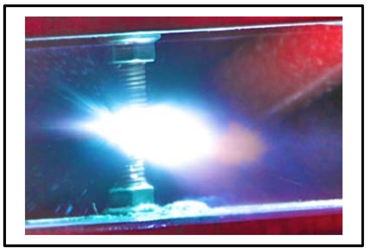
Early (1980's) excess heat observations also resulted in alternative non-nuclear explanations, such as the potential for below ground state hydrogen (Mills, 1980's) [1]. Below ground state hydrogen theory is particularly interesting as it can provide a theoretical basis for catalyst identification, via an extension of the Rydberg equation to below ground state. While aspects of the Mills theory can explain excess heat observations, overall the theory remains inconsistent with transmutation observations, and consequently LENR. We do however, need to be careful not to "throw the baby out with the bath water". By adopting a first principles below ground state hydrogen model, significant progress is possible in developing a theoretical basis for LENR catalyst identification.

Re-examination of the Rydberg Excited State Model
The Rydberg model for the excited states of hydrogen allows transition energies between various states to be theoretically determined, and also poses a size relationship between excited states based on the 'n' variable. The Rydberg excited state size relationship is 'ground state' centred, with excited hydrogen state sizes all being linear multiples of the ground state size.

If we remove 'ground state' centricity, an alternative excited state size model can be identified where each subsequent excited state of hydrogen, n+1, is twice the size of the previous excited state, n. The model can then be extended to below ground states, with each subsequent de-excited state, 1/[n+1], being half the size of the previous state, 1/n.

Why is a Modification of the Rydberg State Size Model Important for Understanding LENR?
The new hydrogen state size model proposes that below ground states of hydrogen are significantly smaller than ground state, for example: $n = 1/5$ will be 2^5 times (i.e. 32 times) smaller than ground state hydrogen. For smaller excited states, (i.e. $n < 1/10$), size approaches that of the larger nuclei.

Various de-excited "small hydrogen" states are expected to be consistent with the characteristics of "small hydrogen" frequently considered to be a vital component of LENR processes. Most importantly, transition energies for the formation of these below ground hydrogen states can now be determined by a first principles extension of the Rydberg equation to de-excited states, noting that some calibration of the theoretical transition energies may still be required.



Photograph - Nickel based LENR Reaction

Testing is in progress to confirm the validity of the model. Details of testing, reaction photography, and list of potential catalysts are available at:
subtleatomics.com

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Steps to identification of main parameters for AHE generation in sub-micrometric materials: measurements by isoperibolic and air-flow calorimetry.

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Introduction. We have introduced since 2011 the use of Constantan wires ($Cu_{55}Ni_{44}Mn_{1}$, CNM), treated to have a sub-micrometric surface texture with an enhanced capability to dissociate Hydrogen (H_2) and/or Deuterium (D_2) from molecular to atomic state. Key reasons for the introduction of CNM were: cost reduction of *active material* (i.e. Pd and its alloys); improvement of the durability of the material, wires (Φ=50-200 μm, l=50-200 cm) activated using pulse heating (ultra-fast cycles from room temperature to 900 °C), and loading/unloading of Hydrogen or Deuterium.

Reactor materials. The reactor body is made of thick borosilicate glass (Schott) working up to 500°C; gas pressures (pure H_2, D_2 or mixed with noble gas Ar, Xe) between 0.05-3 bar. Since 2015 we have used, in the reactor, 3 wires of 125 cm length: Pt (ϕ=100 μm) used both as local thermometer and for calibrations; "standardized" CNM (ϕ=200 μm); "explorative" CNM wire (different ϕ, l, number of wires, thermal pre-treatments, coating, ...). All wires, except Pt, were initially treated with a series of high power electric pulses (up to 50 kVA/g ➔ 900 °C) in order to modify the dimensionality of smooth surface to sub-micrometric by oxidation, following the pioneering work of Y. Arata (Osaka Univ.) on nanomaterials. The specific surface increased thousand times as well as the efficiency of CNM as catalyzer of H_2/D_2 dissociation. Moreover, the surface is several times coated with Low Working Function materials (mainly SrO), according the intuitions/tests of Y. Iwamura (MHI, Yokohama) about the role of electron emission in LENR field. Each wire is inserted into glassy multi-filamentary sheaths, also impregnated by liquid solutions [$Sr(NO_3)_2$, $Fe(NO_3)_3$, $KMnO_4$; later decomposed to oxides], in order to reduce the drawback of sub-micrometric material detaching from wire surface. The borosilicate has the peculiarity of adsorbing large amounts of H (1927, I. Langmuir). Finally, we also made several knots (hole<0.1 mm) along the CNM wires to get non-equilibrium conditions due to the local thermal gradients and high magnetic fields (flowing current up 2.5 A, FexOy magnetism).

Results. In previous experiments we have evaluated AHE (anomalous heat energy) using an isoperibolic procedure being the most appropriated to produce *non-equilibrium conditions* in the system (thermal gradients in this case), as observed by several Researchers in the field. This allowed to measure gains near a factor 2 in the experiments at the highest temperature, although with limited stability over time. Recently, we have decided to compare previous results obtained from the isoperibolic approach with an air flow-calorimetry. During the new experiments, the external wall of the glass reactor has been covered with a double layer of black and thick aluminum foil to further homogenize the internal temperature. The calorimeters consist in a large insulating Styrofoam box with a layer of thick aluminum foil covering the internal surface for improved thermal homogeneity. The calorimeter assembly contains the active reactor and a W lamp inside a dummy reactor for calibrations; these are performed powering the lamp (0->120W->0W, step 20W). Best results to date are the following: A) with a CNM wire with ϕ=100 μm D_2 at 1 bar, internal reactor temperature 500°C, input power 90W the AHE was over 12 +-2W, i.e. over 150W/g, but after 1 day the wire was broken; B) with a CNM wire with ϕ=200 μm it has been necessary to have a Xe-D_2 mixture (each 0.1 bar) and input power of 120 W in order to obtain an AHE of 6-7 W stably for weeks. Qualitatively, such results, and dynamics, where observed twice with 2 different set of wires. It is worthy to note that the behaviors of thin wires was even similar to quite old experiments (50 μm Pd wires): sadly most of the documentation of our old experiments were destroyed by some people at LNF on Feb. 2015. Further work is necessary to improve reliability of the (nice) results (AHE=150W/g; integral of energy over 10MJ/g) obtained by 0.1mm wire.

The "Renaissance" in Nuclear Physics: Low-energy nuclear reactions and transmutations

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Nuclear structure theory has recently undergone an unexpected "renaissance" that can be attributed to two factors: (1) Since 1989, a steady stream of experimental findings has been reported indicating isotopic anomalies in "chemical" systems at energies well below the expected ~10 MeV nuclear level. (2) Since 2007, remarkable *ab initio* super-computer calculations of nuclear properties have been made under the assumption that nucleons have well-defined intranuclear positions ($\Delta x<\sim 2$ fm). Such theoretical work in so-called "Nuclear Lattice Effective Field Theory" (NLEFT) [1-4] runs contrary to the long-established dominance of the Copenhagen interpretation of quantum mechanics (where a low uncertainty in position is associated with high uncertainty in angular momentum). Non-Copenhagen theoretical assumptions that have previously been considered "unconventional", at best, and "pre-modern" at worst [5] are now routinely made as a computational necessity in NLEFT. Moreover, the award by the European Physical Society of the Lise Meitner Award in Nuclear Physics to Ulf Meissner in 2016 for such theoretical work is clear indication that rigorous, numerical reproduction of experimental data trumps all considerations of philosophical "purity".

Following the work of Dallacasa and Di Sia [6] and Di Sia [7] on the in-phase Biot-Savart magnetic attraction between rotating fermions, we have calculated (i) the nuclear binding energies of all stable/near-stable isotopes, and (ii) the magnetic moments of all stable odd-even, even-odd, and odd-odd isotopes whose magnetic moments have been measured experimentally. By specifying the positions of nucleons within a close-packed nucleon lattice, every nucleon is assigned a set of quantum numbers (*n, l, j, m, i, s,* and parity) based solely on its Cartesian coordinates [8-10]. This quantal description of nucleons in the lattice is isomorphic with the symmetries known from the independent-particle model (IPM, ~shell model) of conventional nuclear structure theory. A realistic nuclear force is typically modelled in NLEFT using 40-50 adjustable parameters, but the magnetic interaction between nucleons can be modelled with just 2 parameters, leading to vast improvements in nuclear binding energy and magnetic moment predictions, relative to the traditional shell model calculations.

Finally, we show that LENR transmutation data on Lithium, Nickel, and Palladium isotopes can be simulated using the nuclear lattice and the magnetic nuclear force. Because of the identity between the gaseous-phase IPM and the fcc lattice [8-10], lattice explanations of transmutation effects provide a direct link to conventional nuclear theory. We conclude that funding of LENR research should focus on the basic nuclear science of isotopic transmutation effects, regardless of their possible technological utility. Once the empirical data are unambiguous, *ab initio* computational simulations become possible.

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Influence of Crystal Lattice Defects and the Threshold Resonance on the Deuteron-Deuteron Reaction Rates at Room Temperature

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Based on the cross section measurements of the deuteron-deuteron reactions preceding in metallic as well as in gaseous targets at the deuteron energies of several keV, it could be shown that both the threshold resonance and the electron screening effect are responsible for an exponential-like enhancement of the reaction yields for lowering projectile energies. Angular distributions and the branching ratio of the $^{2}H(d,n)^{3}He$ and $^{2}H(d,p)^{3}H$ reactions could be well described assuming a destructive interference among the 0+ threshold resonance and some highly excited resonances in the compound nucleus ^{4}He. On the other hand, the contribution resulting from the electron screening in metallic environments was estimated by comparing experimental and theoretical reaction yields which are in agreement with experimental data obtained for the gaseous target. A strong correlation of the experimental reaction yields with the number of crystal lattice defects was observed, which could be explained by increasing the effective electron mass in case of a small contamination of the target surface by oxygen and carbon atoms. The latter effect changes the fusion reaction rates extrapolated down to the room temperature by many orders of magnitude and might clarify the strong target material dependence of the heat excess production in the room temperature experiments.

Positive Result of a Laser-Induced LENR Experiment

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After 3 years and 37 tests of laser-induced Low Energy Nuclear Reaction (LENR) experiments, a single apparent excess heat result was observed. Other experiments were performed, duplicating the Martin Fleischman Memorial Project (MFMP) “Glow Stick” device, but no observable excess heat was recorded in those experiments.

Somewhat similar to the work of D. Letts, D. Cravens and P. Hagelstein[1], using laser excitation to initiate LENR excess heat, Phonon Energy Inc. developed a larger test fixture (figure 1) that used an infrared laser to stimulate heated nickel powder (Hunter Chemical Grade AH50) that was conditioned under vacuum and pressurized 99.995% pure hydrogen gas.

We theorize that the specially tuned laser generates plasmons between antennae, and other surface protrusions, near the surface of a fine Nickel (Ni) metal powder fuel. A secondary reaction is then thought to occur on the surface of the nickel fuel between the densely packed hydrogen atoms and the Nickel atoms within the metal lattice. Although the exact nuclear process is still unproven, we postulate that the well known Widom-Larson[2] theory may have been at work.

In a heated, high-pressure Ni-H_2 reaction chamber, an integrated excitation laser was used at increasing step-levels of power as part of a test procedure. After some 4.5 hours of testing, four temperature sensors within the Ni powder recorded a sudden ramp up of temperature at a rate of approximately 19.5 deg. C per hour while constant background heater and laser power settings were held. The test chamber’s background heater was continued to be maintained at a constant power setting while the laser was then switched off. However, the rate of temperature rise continued for some 45 minutes until the test was terminated (Figure 2).

Figure 1. LENR setup

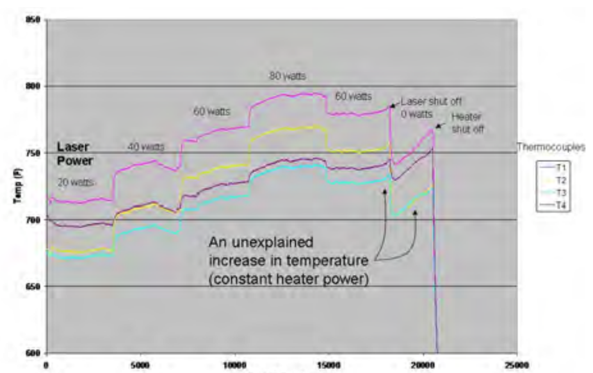

Figure 2. Unexplained test temperature rise

The test was replicated several times using identical methods and materials, but no excess heat was observed in any of the follow-on experiments. Present and future testing has been discontinued.

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Alternatives To Calorimetry

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Since the first publication of Martin Fleischman and Stanley Pons in 1989, the majority of articles in the LENR field have focused on calorimetry. [1] This is true for both electrolysis experiments and gaseous loading experiments. [2]

Many calorimetry experiments are masterpieces of science [3] Nevertheless, despite the experimental evidence, the results indicating excessive heat have not convinced the scientific community. Well-designed calorimetry experiments are slow to develop. It's an issue, because it would be good to test many alloys systematically. It is likely that there are still unknown alloys whose ability to generate what Ed Storms calls a "Nuclear Active Environment" [4] is greater than that of palladium. It is certain that low concentrations of elements such as lithium, boron, beryllium in these alloys will have undoubtedly positive effects. We need fast and reproducible tests to sort all these alloys and select the most promising samples. Several authors have suggested that the quantum condensation of deuterium nuclei is at the root of the appearance of "NAE" [5] [6] [7] [8]

For this purpose, we propose three simple techniques to implement:

1) The "Fusion Diode" effect: deuterated alloys in contact with a semiconductor cause the appearance of an easy-to-measure electrical voltage. If this voltage is actually due to the direct conversion of LENR, we have a simple method to select the most promising alloys.

2) The Reifenschweiler effect [9]: the variation of tritium beta-rays bremsthralung conversion efficiency as a function of temperature is also a simple method for sorting the most efficient alloys. [10]

3) The magnetic alignment of the tritium pairs: this effect, which we have postulated, but not yet observed, would make it possible to very quickly test many new alloys. [11]

4) The rare neutrons observed are one of the most indisputable proofs of the reality of LENR. A new and extremely sensitive method of detecting neutrons in the 4Pi of space around a LENR device will also be discussed, along with two new improved calorimetry methods.

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Temperature Dependence of Excess Heat in Gas-Loading Experiments

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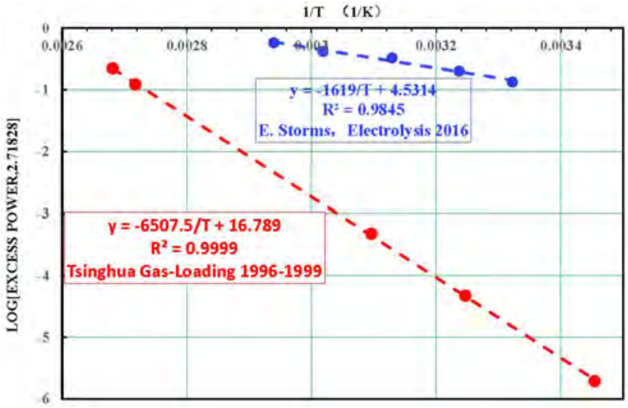
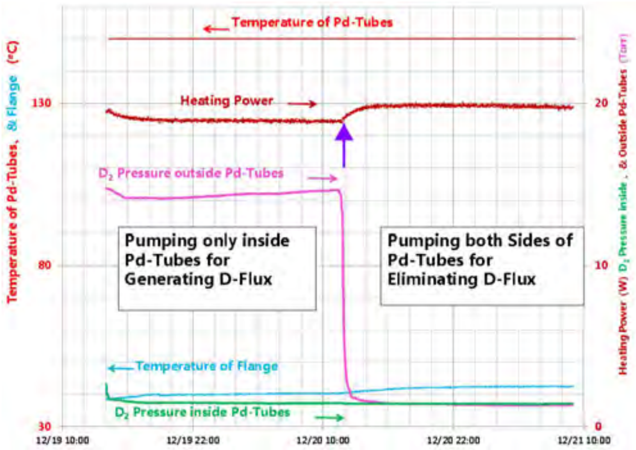
Two additional sets of data support the temperature dependence of excess heat-- a straight line in semi-logarithmic plot published by E. Storms.



(1) In 1996-1999, a series of gas-loading experiments were conducted at Tsinghua University in order to detect the temperature dependence of excess heat. A long-thin Pd-wire $(250mm \times \phi 0.34mm)$ was immerged in deuterium gas. The Pd-wire was heated to a specified temperature (50, 95, 100 °C) by a computer-controlled DC power supply. When we pumped out the deuterium gas, the de-gassing process on Pd-wire was supposed to be an endothermic process; however, the necessary DC power for keeping the specified temperature was dropped. It showed an exothermic process in Pd-wire with pumping. This exothermic effect could be quantitatively measured by the reduction of DC power. Two more data points at (35, 16.5 °C) were obtained using cooling curves and temperature cycling methods without pumping Fig.1 shows these excess heat effects at 5 temperatures They are on a straight line (red line) similar to that discovered by E. Storms in heavy-water electrolysis experiments (blue line).



(2) In 2010~2014, in order to confirm the effect of deuterium flux and exclude the heat-conducting effect of deuterium gas, a series of gas-loading experiments were conducted using a bunch of 7 Pd-tubes $(7 \times 400mm \times \phi 2mm \times 0.08mm)$ in a vacuum chamber. The Pd-tubes were heated to 150°C by a computer-controlled DC power supply again. The deuterium gas was filled into the chamber outside of Pd-tubes only while the gas inside of Pd-tubes was pumped out. Thus a deuterium flux would diffuse through the thin wall of Pd-tubes. Next day morning, we pumped both sides of the Pd-tubes to stop the deuterium flux. The data showed a clear increase of DC power (Fig.2, red line, purple arrow), although the necessary heating power for a specified temperature was supposed to decrease due to the reduction of heat-conducting of deuterium gas. Evidently, it showed that the deuterium flux before 12/20/12:00 induced the excess heat. Pumping per se did not induce the excess heat.

Two sets of data supported not only the temperature dependence of excess heat in gas-loading experiment, but also revealed the diffusion nature of this straight line. Consequently, a resonant surface capture model has been proposed to relate this inelastic process (excess heat of nuclear reaction) to an elastic process (diffusion process in crystal scale) (see another abstract for ICCF-21).

Chemical and Nuclear Catalysis Mediated by the Energy Localization in Hydrogenated Crystals and Quasicrystals

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Catalysis is at the heart of almost every chemical or nuclear transformation process, and a detailed understanding of the active species and their related reaction mechanism is of great interest. An important parameter of the reaction kinetics is the *activation energy*, i.e. the energy required to overcome the reaction barrier. The lower is the activation energy, the faster the reaction rate, and so a catalyst may be thought to reduce somehow the activation energy. Dubinko et al [1] have shown that in a crystalline matrix, the activation energy may be reduced due to *localized anharmonic vibrations* (LAVs) of atoms, LAV can be excited thermally or by irradiation, resulting in a drastic acceleration of *chemical reaction* rates driven by thermally-activated 'jumps' over the reaction barrier due to the time-periodic modulation of the barrier height in the LAV vicinity.

At sufficiently low temperatures, the reaction rate is controlled *by quantum zero-point vibrations (ZPV)* rather than by thermal fluctuations. Large amplitude atomic motion in LAVs may result in time-periodic driving of adjacent potential wells occupied by hydrogen ions (protons or deuterons) upon hydrogenation. This driving is shown to result in the increase of amplitude and energy of zero-point vibrations (ZPVs). Based on that, we demonstrate a drastic increase of the D-D or D-H fusion rate with increasing number of modulation periods evaluated in the framework of Schwinger model [2], which takes into account suppression of the Coulomb barrier due to ZPVs, which is further enhanced by LAVs. In this context, we will present numerical solution of Schrodinger equation for a particle in a non-stationary double well potential, which is driven time-periodically imitating the action of a LAV [3]. We show that the rate of tunnelling of the particle through the potential barrier separating the wells can be enhanced enormously by the driving in a certain frequency range.

We will present atomistic simulations of LAVs in the crystal lattice of Ni, Pd, Ti-Zr-Ni and in their quasicrystaline nanoclusters.

We will present experimental results on the interaction of the Ni, Pd and Ti-Zr-Ni crystals and quasicrystals with hydrogen and deuterium under thermal equilibrium and under gamma irradiation, which is introduced as an efficient tool for the athermal production of LAVs.

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George Egely (Hungary)

Electric Energy Generation by LENR

ICCF-21, Abstract.

The paper is about the lost, forgotten inventions, when high voltage electric pulses were produced with LENR a plasma process of several kilowatts.

While most research effort was devoted to electrochemical LENR studies in the past decades, plasma-based studies are gaining ground also.

Historically, pulsed hydroged plasma devices were the basis of the best clean energy devices during the past 100 odd years. Their mere existence is a novelty for LENR researches. The reason is simple: even their inventors were not aware of the physical mechanisms, and their fundamental process. All of these methods were based purely on lucky accidents, then developed by trial and error. Lacking the very fundamentals of excess energy by LENR, inventors thought they were harnessing the energy of "ether."

The earliest successful devices were developed by Nikola Tesla, and Henry T. Moray. The former did not leave much technical data for us – apart from his high voltage, high frequency carbon electrode discharge lamps which produce the right circumstances to initiate LENR reactions.

Henry Moray left us many more technical details, a patent, photographs, and a number of descriptions from witnesses. Both of them worked from the 1910's to the 1940's, well before the very concept of fusion, or the structure of the nucleons was known. Since then some other inventors have found the same effect but in different technical setups.

However, mainstream science preceded them. Up to July 1914, several papers were published about transmutation of hydrogen into helium and neon, in pulsed, high voltage, discharge tubes.

The aim of this paper is twofold: to show the history of forgotten technical inventions based on LENR, and to show their common physical roots.

The common physics of these forgotten inventions is based on the step–by-step transmutation of hydrogen into deuterium, tritium and helium. Sharp edges and cavities on the surface of high voltage cathodes are the very locations where energy is released. This can be found in all the forgotten inventions.

The renaissance was in the 1980's, when the Russian Chernetzkij and the Canadian Correas developed their devices. This happened just before the days of Pons and Fleischmann, when the necessary concepts of LENR were gradually born.

Electric, mechanical and chemical energy production by LENR is more economic than low grade heat, yet these paths are neglected by researchers of LENR. The author has a 10-odd years of hands-on experience with the difficulties and pitfalls of these devices.

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George Egely, Maria Balint, Farkas Rosko (Hungary)

Changes of Isotope Ratios in Transmutations

ICCF-21, Abstract

Transmutation in a low energy environment is a complex, unexplored phenomena. Its inner mechanisms are hotly debated and even its existence is denied by some ultra-conservative nuclear physicists. Although there are numerous test results to prove it, this phenomenon is not widely accepted, due to the difficulty in reproducing it.

The aim of the paper is twofold:

-To describe transmutation in transient dusty plasma, where reproducibility is guaranteed,

-To examine shifts in isotope ratios of different elements, which may help theoreticians to further elaborate on the mechanism of LENR.

ICP-MS is a well-known tool in research but recently the high sensitivity mass spectrometers have become available.

Further: laser-ablation is also available and it helps to get test results without solvents; thus the reliability of transmutation tests is further improved.

There are some strange conclusions of these tests.

- It is possible to transmute lighter mass elements, like carbon, oxygen and nitrogen via one or two fusion steps into medium mass elements, like iron, zinc, copper.

- There is no major energy release in this process, contrary to expectations.

- The daughter elements are usually neutron-rich.

Most probably this is the consequence of additional synthesis of neutrons, which is an energy consuming endotherm process. Thus the net energy balance is nearly around zero. Excess energy of fusion is spent on excess neutron generation.

Isotope shift analysis thus helps to figure out the fusion processes in nature.

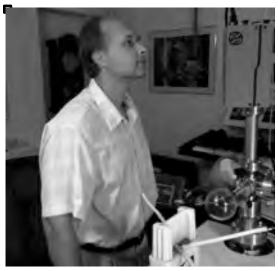
Our test results support this idea; the paper will present several of these ones.

Mainstream science considers transmutation as a rare event, taking place inside stellar interiors supernova explosions, and neutron star mergers. Our test results prove otherwise.In our table top, 1 KW input reactor, such fusions are commonplace. Heavier than iron elements have been made with fusion as well, like Zr40, Sn50, Nd60, W74, and even Pb82, Th90.

The low energy transmutation/fusion may account for some excess heat of the Earth, and also for the geysirs of Enceladus (Saturn's tiny moon).

Nature is rich in these natural transmutation processes but they are usually ignored or explained away.

Transmutation is far more frequent in nature than expected by recent mainstream science. So apart from slow neutron capture and rapid neutron capture, there is a low energy transmutation in nature at modest energy levels.



Synthesis of Lanthanides on Nickel Anode

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In April of 2017 I have conducted a replication of Sternglass' neutron synthesis experiment [1] using nickel 20Cb3 alloy 1" round bar for anode instead of copper as follows:

- I used a demountable X-ray tube filled with hydrogen at 0.01 Torr;
- Using Spellman DC power supply I have created a ~30 kV/20 mA electron beam via field emission from cold aluminium cathode;
- I was turning the beam on and off in 3-minute intervals and recording neutron counts per minute using a bank of five helium-3 detectors protected by a 4-mm thick solid-steel Faraday cage; the average counts were 39.0 CPM during the beam-on and 28.7 CPM during beam-off intervals (P = 0.0007).
- The entire experiment lasted for about 20 minutes and towards the end the electron mean has created a noticeable crater on the anode – Fig. 1.

Just now I analysed the anode in the Amray 1830 electron microscope fitted with Si(Li) EDS and determined that almost the entire bottom of the crater is coated in lanthanides. Lanthanides (primarily Lanthanum, Cerium, Praseodymium and Neodymium) are visible to naked eye as a yellow spot that covers the area of approximately 3 mm^2 (Fig. 1 – Left). EDS spectrum of the area (Fig. 1 – Right) reveals that lanthanide peaks completely dominate the EDS spectrum with *all of the expected peaks clearly resolved*; there are no nickel peaks present in the densest spots (not shown).

<u>Conclusion:</u> 30 kV/20 mA electron beam impinging on nickel anode in hydrogen atmosphere results in well-resolved neutron flux and apparently causes profuse transmutation that creates macroscopic quantities of foreign materials (e.g. lanthanides) on nickel surface. In the next series of experiments I am planning to capture high-resolution X-ray, neutron and gamma spectrum in real time as well as conduct a systematic analysis of the anode before and after the experiment to put quantitative limits on the amount of new elements produced and achieve better control of the process.

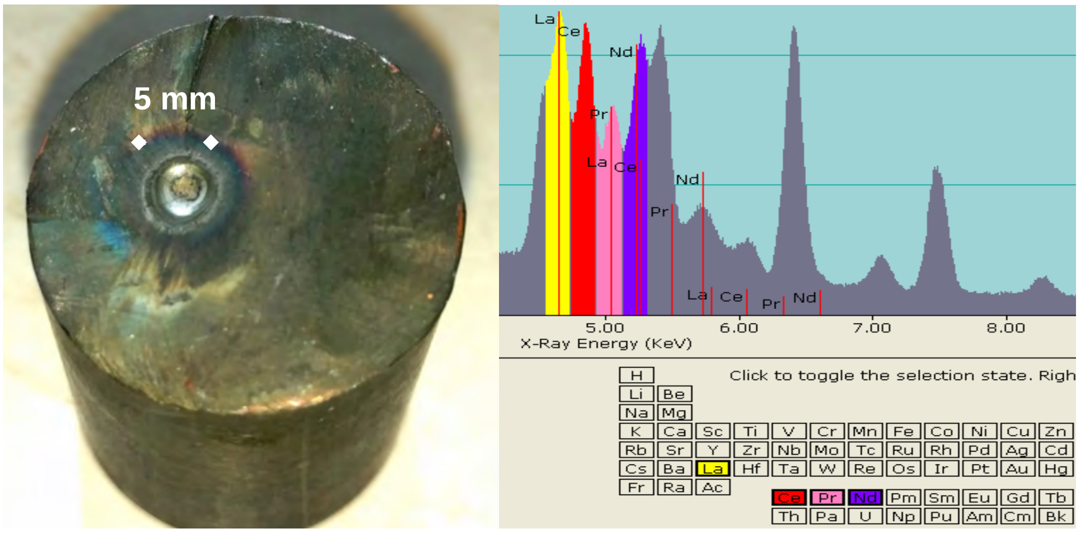

Fig. 1. Left – lanthanide area (yellow) at the bottom of the crater formed on nickel anode by electron beam; Right – lanthanides are prevailing elements in the area, their peaks dominate EDS spectrum.

[1] M. Fomitchev-Zamilov, Neutron Synthesis via Arc Discharge in Low-Pressure Hydrogen Plasma: Successful Replication of Earnest Sternglass Experiment, ICCF20, Sendai, Japan, 2016

Reliable Neutron and Gamma Radiation Detection

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Reliable neutron and gamma radiation detection is critical for nuclear science in general and for LENR experimentation in particular. In this tutorial I summarize best practices for multi-mode neutron and gamma detection including:

- Bubble detectors;
- Helium-3 and boron detectors;
- Neutron activation / gamma detection;
- Gamma shielding and gamma rejection;
- Neutron moderation and reflection;
- Makeshift neutron sources and their regulatory implications;
- EM noise screening;
- Statistical analysis of measurements in order to establish validity of results.

In conclusion I present a turn-key hardware / software solution that satisfies majority of experimenter's needs by offering exceptional sensitivity to signal while being virtually impervious to electromagnetic noise (Fig. 1). The developed hardware / software system allows monitoring, auditing, aggregation and statistical analysis of neutron and gamma counts and spectra originating from multiple devices communicating wirelessly via WiFi.

1.
Fig. 1. Touch-screen helium-3 neutron detection system with WiFi in Faraday enclosure.

Space Application of a Hybrid Fusion-Fission Reactor

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JWK Corporation and Global Energy Corporation have spent the past two decades understanding and developing Condensed Matter Nuclear Reactions with the US Navy and NASA. This has resulted in a US Patent, 8,419,919 "System and Method Generating Particles", that has been replicated and published in over 50 peer-reviewed papers. We have observed energetic particles during Pd/D co-deposition [1, 2] including ≥ 1.8 MeV protons (with 15 MeV protons), ≥ 7 MeV alphas, and 2.5 MeV and 14.1 MeV neutrons [3]. These neutrons are energetic enough to fission uranium as was reported in 2016 [4] with an average energy > 6 MeV.

Deep space missions are dependent upon ^{238}Pu thermoelectric generators (RTG) providing less than 1 kW of electrical power. With the exception of the solar powered Juno probe, every spacecraft destined past Mars has been RTG dependent. Consequently, deep space missions are power deprived for both instrumentation and propulsion. Indeed, human travel beyond the Earth-Moon system requires nuclear electric propulsion if astronauts are to arrive healthy.

Global Energy Corporation (GEC) began developing a non-fissile reactor core suitable for deep-space power. GEC has a second Space Act Agreement with NASA Glenn Research Center to develop a launch-compatible design, operating at the Plum Brook Station facility. Plum Brook has vacuum, acoustic and shake table systems to certify space launch capability. Various electrical power needs range from tens of kilowatts for instruments to over 20 megawatts for human space craft electric propulsion and planetary power.

(Hermes Spacecraft, "The Martian", 20th Century Fox.) (NASA Plum Brook Space Power Facility)

[1] P.A. Mosier-Boss, F.E. Gordon, L.P. Forsley, D. Zhou, "Detection of high energy particles using CR-39 detectors Part 1: results of microscopic examination, scanning, and LET analysis," *Int. J. Hydrogen Energy*, **42**, no. 1, pp. 416-428, (2017)
[2] A.S. Roussetski, A.G. Lipson, E.I. Saunin, F. Tanzella, M. McKubre, "Detection of high energy particles using CR-39 detectors Part 2: results of in-depth destructive etching analysis," *Int. J. Hydrogen Energy*, **42**, no. 1, pp. 429-436, (2017)
[3] P.A. Mosier-Boss, S. Szpak, F.E. Gordon, L.P.G. Forsley, "Triple tracks in CR-39 as the result of Pd/D co-deposition: evidence of energetic neutrons," *Naturwissenschaften*, **96**, no.1, pp. 135-142, (2009).
[4] P.A. Mosier-Boss, L. P. Forsley and P. McDaniel, "Investigation of Nano-Nuclear Reactions in Condensed Matter: Final Report", *Defense Threat Reduction Agency*, pp 41-49. (2016)

Development of a Sensitive Detection System for the Measurement of Trace Amounts of He^4 in Deuterium or Hydrogen

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Many LENR systems seem to generate He^4 from deuterium but there are few systems that can detect trace amounts of He^4 in the presence of D_2. Most commercial magnetic sector systems are large and expensive and while they have excellent Δm/m resolution, they still require a getter system to achieve ppb sensitivity. We have developed a lower cost and compact system that allows us to measure He^4 down to sub 100 ppb levels in D_2. This system utilizes a column of activated carbon at LN_2 temperature that effectively absorbs everything but Helium. Post absorption, the system uses a MKS Microvision and a SRS 100 RGA to check for helium purity. The helium eluted from the column is quantified by a small magnetic sector mass spectrometer tuned to mass 4. A typical sample size required to achieve low ppb sensitivity to He^4 is 50 cc at 50 torr. Calibrations have been done with air, He^4 in D_2 at various concentrations and show a 3% variation from standard sample to standard sample. We will discuss our operational experience with this instrument and show results from various calibrations using different carrier gases. We are evaluating both steady state and pulse modes along with appropriate data analysis methods. More recently we have begun to consider the analysis of samples other than gas. We have implemented a tube furnace to heat samples to desorb He^4 from samples such as metal foils. We are also developing a system to electrically heat metal samples to desorb He^4. Preliminary results with these systems will be discussed.

Elliptical tracks and magnetic monopoles

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In a number of studies, electric discharges in water instrumented with nuclear track detectors show a collection of tracks which have yet to be conclusively identified. The same tracks are produced in a simpler way using a brief flash of light with photographic emulsions. Using the simpler method, evidence is reported for quantized elliptical tracks in photographic emulsions with sizes expected of bound magnetic monopoles, yet *requiring* velocities greater than the speed of light, indicating particles with superluminal electric charge. Geometrical analysis using analogy with the electron indicates a bound magnetically charged particle with mass $m_m = 1.45 \times 10^{-3}$ eV/c^2 with superluminal velocities. Using the extended relativity of Recami and Mignani, m_m is the relativistic mass of a *superluminal* electron, with $m_0 = 5.11 \times 10^5$ eV/c^2.

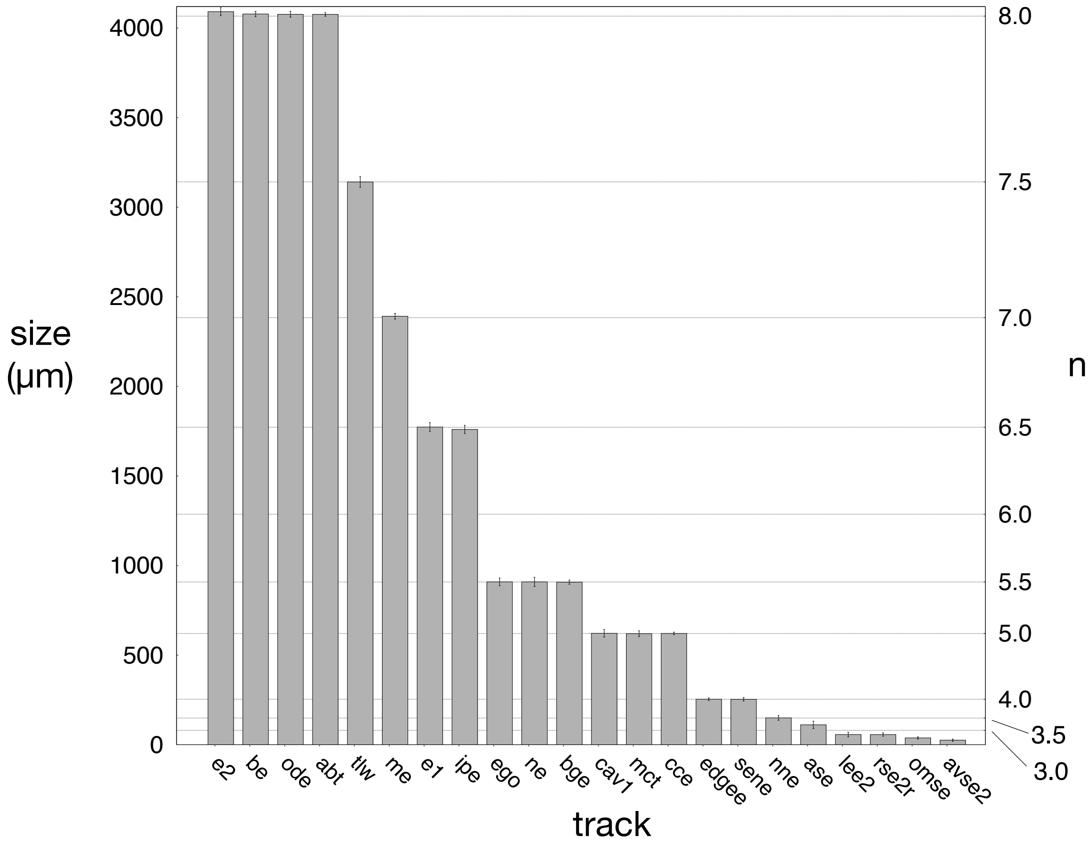

FIG. 1. Quantized ellipse semi-major axis sizes. Ellipses between n = 8 and n = 3.5 are shown to be quantized as half integer values. Ellipses less than n=3.5 are quantized by quarter integer values.

A Geometric Understanding of Low Energy Nuclear Reactions in the Palladium-Deuterium Lattice

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Our physical understanding of the universe follows from an investigation of the position of objects in space and of the change in those positions over time. Such investigation results in information concerning the patterned regularity or apparent randomness of the interaction of said objects. Such objects are generally defined by some set of qualitative properties and can be either immediately perceived by the senses or inferred based on a perceived pattern of interactions of other, directly or indirectly observed objects. Direct perception results in a localization of those qualities in space. Inference can suggest either a localization of those qualities or a diffusion, bounded or not, of those qualities throughout the neighboring space as in the notion of an extended quality or field. Such fields in turn can be thought of as either extensively self-existent or as proceeding from some localized source and/or proceeding to some localized sink. In the case of a source/sink, the qualitative intensity or density which defines the field generally varies as a function of the change in position or over time of some locus of the field with respect to its source or sink. Oscillation of field intensity/density lends itself in turn to wave analysis of physical phenomena. Current physical theory tends toward the wave/ field model as a means of explaining and calculating all physical object interaction.

A result of this development in physical thinking is that the interaction of all properties and their elaborations such as mass, momentum, action, force, energy, power, charge and spin, among others, are localized in their objective perception according to well-defined, multi-dimensional geometric constraints. Thus the various fundamental particles of matter, be they quarks and leptons or their presently conceived composites, nucleons and atoms, are found to interact, even when highly energized, according to geometric constraints. This is found in the various depictions of electron orbitals, which are graphic representations of electron probability density. In the state of condensed matter, as in the case of metallic crystals, the geometric configuration and interaction is pronounced via these orbitals, both with respect to the elemental atomic structure and the admixture of any other elements. Such geometric, patterned alignment can be seen in the lattice for the electron bonding and the nuclear localization of both the crystal element and its absorbed element.

The palladium-deuterium lattice is a pre-eminent example of this dynamic geometry. The charge field strength of the two elements is such that the electronegativity of hydrogen and palladium is an identical 2.20, and in the context of the face centered cubic or cuboctahedral lattice of palladium, any hydrogen or deuterium introduced to the lattice via electrolysis and conducted toward the interior via covalent bonding will have its nucleus positioned directly in the center of the triangular lattice aperture to an interior tetrahedral interstitial chamber formed by three co- planar palladium nuclei. Said nucleus thereby achieves precise target confinement for the nuclear projection of any absorbed deuterium atom located in the tetrahedral chamber, in response to excitation of an adjacent palladium 5s orbital, thereby resulting in clean, low energy nuclear fusion and the production of helium. This is the basis of the Fleischmann - Pons experimental phenomena and for sustained and virtually inexhaustible, clean energy production for the future.

[1] M. Gibson, “Low Energy Nuclear Reaction” YouTube video, https://www.youtube.com/watch?v=3RiZxqZVoBY&t=40s, 2015.
[2] M. Gibson, “Low Energy Nuclear Reaction audio enhanced” YouTube video, https://www.youtube.com/watch?v=1Z7FXK_2CAc, 2017.

Real-time Instrumentation and Digital Processing for LENR Characterization

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Optical Infrared (IR) measurements of 'active' Pd/D cathodes in real time, at the Navy's SPAWAR Laboratory and UCSD in San Diego, showed that LENR phenomenon take place on time-scales short relative to the response time of most calorimeters. SPAWAR further substantiated these results when Pd/D cathodes were directly codeposited on the surface of poled PZT ceramic transducers. A review of the electrical properties of these transducers showed that they belong to the class of ferroelectric materials which are simultaneously both pyroelectric and piezoelectric but on widely different time scales.

Motivated by these results and the belief that it's hard to optimize something that you can't measure, we have developed a number of real-time measurement techniques that simultaneously gather and processes multi-channel data on a 24/7 bases. The instrumentation system is based on a 14-channel USB LabJack™ 14-bit DAQ system typically operating at about 500 samples/second and includes real-time computer display and Excel processing of the recorded data on the same computer with only a two-minute latency. Both raw data and processed results are archived. The following sensors have been employed and will be described along with their advantages, limitations, and implementations including a summary of our findings:

Temperature: Thermocouples, RTDs and pyroelectric sensors for temperature change;
Magnetic field: Hall effect sensors;
Gamma rays: Digital Geiger-Müller and NaI scintillation energy-spectrum detectors;
Neutrons: PRESCILA fast neutron detector and He3 thermal neutron detector;
RF radiation: USB RF spectrum analyzer;
Acoustic radiation: Piezoelectric sensor and audio spectrum analysis;
Cell operating characteristics: Electrochemical immittance and transfer-function spectroscopy.

Documentation and Archive of 29 Years of LENR Research by Dr. Edmund Storms

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Studies of LENR has been ongoing worldwide for 29 years, generally resulting in failure to achieve universally accepted understanding of the process. Patterns hidden within the many studies could reveal important missing understanding if the results were reexamined with the perspective of present knowledge. For this reason, researchers should be encouraged to examine their experience and share the results with other researchers. To this end, Dr. Grimshaw has undertaken a project to organize the past LENR measurements of Dr. Storms so that his experience can be reevaluated and shared.

Dr. Storms began research in LENR soon after it's 1989 announcement. These investigations took place on a foundation of many years of research in high-temperature materials at Los Alamos National Laboratory (LANL), where he worked on the nuclear rocket and nuclear power in space programs. The body of research involving LENR consists of a several types of records: 1) publications and unpublished progress reports; 2) laboratory notebooks; 3) electronic files for documents and experimental data; and 4) hard-copy materials in storage. Also included in the project are and three rounds of interviews of Dr. Storms' for his observations regarding his research career. His extensive LENR library is also included.

Dr. Storms' LENR publications include about 125 items. They include his two books, published in 2007 and 2014. Unpublished progress reports, mostly to sponsors of his work, include more than 110 reports. His 10 lab notebooks document LENR research from 1995 to 2015. A work history prepared by Dr. Storms from these notebooks consists of about 2750 entries. The electronic files are on current and legacy media, including an active computer, CDs, DVDs, ZIP disks, VHS tapes, an external hard drive, and 3½-inch floppy disks. A dozen hanging file tubs of hard-copy records were assembled. The LENR library contains more than 6000 papers and similar items. It is one of the largest collections of materials on the topic in existence.

Organizing and archiving such a voluminous collection for additional analysis requires considerable time and dedication. Nevertheless, researchers are encouraged to use this approach to organize and further evaluate their early studies.

Parametric experimental studies of Ni-H electrochemical cells

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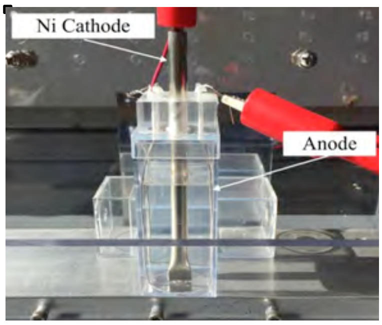
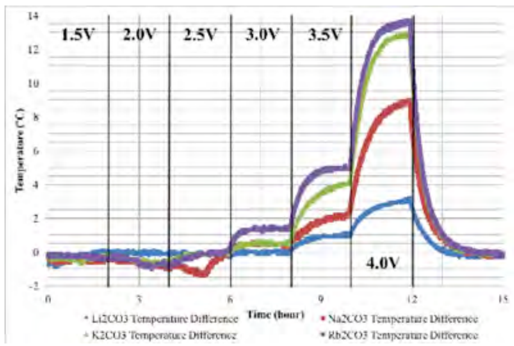
Electrochemical interactions between nickel and protons were heavily studied in the early 1990s and during the following years [1-5]. The Ni-H system is not much studied now, despite the early reports of strong excess power results, and the fact that nickel and light water are significantly cheaper than palladium and heavy water. We are pursuing a three-part research program with experiments, data analyses and simulations aimed at understanding Ni-H electrochemical approaches to producing LENR. This paper reports on experimental results. Two other papers deal with the data analyses [6] and multi-physics simulations [7].



We are using small (26 mm square and 62 mm high on the inside) rectangular cells that are available commercially at modest cost. We added a glued plastic piece to the cap that contains five holes, one for the cathode in the center and four near the corners for the platinum anode wires. The cathode is 99.5% pure nickel tube with an outside diameter of 6.5 mm and a wall thickness of 0.5 mm, which was bought from Goodfellow in the U.K. The use of tubular cathodes has two advantages. The tubes are dimensionally and positionally stable during experiments. And, it is possible to put sensors into the tubes during runs. Two commercial Type J thermocouples are used, one inside of the nickel cathode and one in the air directly above the first. The difference between the two gives the temperature of the cell interior relative to the ambient.

Four alkali metal carbonate electrolytes are studied, following the early experiments, with applied voltages in the 0.5 to 5.0 V range. Besides monitoring temperatures and the current, we are able to record cyclic voltammograms and open circuit voltages, as well as measure five types of spectroscopy (Impedance, Optical Reflection, RF Emission, Sound Emission and Electrical Noise) and record thermal infrared images. The second figure shows example data, the cell temperatures as a function of electrolyte and applied voltage.



[1] R. L. Mills and P. Kneizys, "Excess heat production by the electrolysis of an aqueous potassium carbonate electrolyte and the implications for cold fusion", Fusion Tech., Vol. 20, p. 65 (1991).
[2] V. C. Noninski, V.C. and C.I. Noninski, "Determination of the excess energy obtained during the electrolysis of heavy water", Fusion Technology, Vol. 19, p. 364 (1991)
[3] R. T. Bush, "A light water excess heat reaction Suggests that 'Cold Fusion' may be 'Alkali-Hydrogen Fusion'", Fusion Technology. Vol. 22, pp. 301 – 322 (1992).
[4] R. Natoya and M. Enyo, "Excess heat production in electrolysis of potassium carbonate Solution with nickel electrodes" in "Frontiers of Cold Fusion", pp. 421-426 (1993)
[5] B. Holverstott, "Randell Mills and the Search for Hydrino Energy", KRP History, p. 87 (2016)
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[7] G. Papadatos, Z. Awtry, Llewellyn Richie, D. J. Nagel, "Electrical and thermal simulations of Ni-H electro-chemical cells", This Conference

Statistical mechanics models for the PdH_x and PdD_x phase diagram with both O-site and T-site occupation

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In past years we developed statistical mechanics models for bulk PdH_x separately for the alpha phase [1] and for the beta phase [2], and also to model the isotherms of the phase diagram [3]. We recently extended this analysis to develop a similar model for the phase diagram of PdD_x.

One issue encountered concerns the data sets available for PdD_x. For PdH_x it was possible to make use of previous work that was put into the development of a phase diagram based on individual isotherm measurements. There do not appear in the literature analogous phase diagrams constructed for PdD_x.

A second issue encountered concerns extrapolation into regions of higher loading. For PdH_x it was possible to make use of experimental data at relatively high loading and high temperature to develop plausible extrapolations. However, there are fewer available data sets for PdD_x, and these do not permit an analogous extrapolation.

[1] P. L. Hagelstein, "Empirical models for octahedral and tetrahedral occupation in PdH and PdD at high loading," J. Condensed Matter Nuclear Science, vol. 17, pp. 35-66, 2015.
[2] P. L. Hagelstein, "O-site and T-site occupation of α-phase PdH_x and PdD_x," J. Condensed Matter Nuclear Science, vol. 17, pp. 67-90, 2015.
[3] P. L. Hagelstein, "Models for the phase diagram of palladium hydride including O-site and T-site occupation," J. Condensed Matter Nuclear Science, vol. 20, pp. 54-80, 2016.

Phonon-mediated excitation transfer involving nuclear excitation

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A few years ago we identified a relativistic mechanism for phonon-nuclear coupling [1] in connection with developing models for anomalies in Condensed Matter Nuclear Science. Since phonon energies are limited to less than 1 eV there is no possibility for single-phonon emission from an excited nuclear state in the keV range or higher. The lowest-order interaction which could give rise to observable effects is excitation transfer, in which the nuclear excitation is transferred to another nucleus sharing a common phonon mode.

Excitation transfer can produce delocalization and phase coherence, effects which are potentially observable in dedicated experiments. An unambiguous experimental result showing such an effect has the potential to prove the existence of the phonon-mediated nuclear excitation transfer, as well as to verify experimentally the existence of the phonon-nuclear coupling mechanism. Experiments are underway in our group to explore excitation transfer effects.

We have previously proposed that excitation transfer may be responsible for low-level energetic alpha and neutron emission in Fleischmann-Pons experiments [2]. Here we consider possible new experiments in which excitation transfer involving $D_2/^4He$ and $HD/^3He$ transitions to disintegrate nuclei, giving energetic alpha, proton and neutron signals that might be associated with specific excitation transfer reactions. If correct, such excitation transfer experiments would have the potential to allow for a study of mechanisms and specific reactions, and help shed light on what is going on in excess heat experiments.

[1] P. L. Hagelstein, "Quantum composites: A review, and new results for models for Condensed Matter Nuclear Science," J. Condensed Matter Nuclear Science, vol. 20, pp. 139-225, 2016.
[2] P. L. Hagelstein, "A unified model for anomalies in metal deuterides," Proc. ICCF9 pp. 121-134, 2002.

Phonon-nuclear coupling matrix element for the low energy E1 transition in Ta-181 and applications

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Quite a few anomalies have been reported on in the past 29 years in which various stimulations provided by the local condensed matter environment result in effects either unambiguously nuclear, or which permit an interpretation of having a nuclear origin. Such effects seem anomalous, especially since what goes on inside of a nucleus is generally thought to be only weakly impacted by the local condensed matter environment, or by the associated relatively slow center of mass dynamics. The clean separation of the center of mass and relative degrees of freedom in the nonrelativistic quantum composite argues against the existence of a significant coupling between them. The second-order electric and magnetic interactions are just too weak to produce anomalies of the sort claimed.

Things are different for the relativistic quantum composite. In this case there is a low-order coupling between the center of mass motion and internal degrees of freedom [1]. This coupling was first noted by Breit in 1937, and has received only modest attention over the years. From our perspective, this obscure relativistic interaction has the potential to mediate anomalies. We have been interested in the development of theoretical estimates for the associated phonon-nuclear coupling matrix elements, and also in the question of whether this coupling can be isolated in simple physics experiments.

We have recently carried out a computation of the interaction matrix element in the case of Ta-181, which has a low-energy E1 transition at 6237 eV. This calculation was based on a boosted version of the LS-coupling interaction in the case of a single proton transition in a deformed nuclear potential. This approach accounts adequately for the systematics of shell occupation in this mass region, and agrees with the observed quadrupole moment. However, the radiative decay rate computed in this way is high by orders of magnitude, a problem which remains open even today in nuclear physics. We consider an R|ST separation which would allow for a screening effect that might account for the discrepancy in the radiative decay rate, but would have much less of an impact on the phonon-nuclear matrix element.

Experiments are ongoing in our lab focusing on the low energy M1+E2 nuclear transition in Fe-57 at 14.4 keV. Since the **a**.c**P** operator for phonon-nuclear coupling requires E1 symmetry, there cannot be nuclear transitions between the ground state and the 14.4 keV state mediated by single phonon exchange. Instead, coupling is possible through two E1 transitions, so that the lowest order interaction involves a two-phonon interaction.

[1] P. L. Hagelstein, "Quantum composites: A review, and new results for models for Condensed Matter Nuclear Science," J. Condensed Matter Nuclear Science, vol. 20, pp. 139-225, 2016.
[2] G. Breit, "Approximately relativistic equations for nuclear particles," Physical Review, vol. 51, pp. 248-262, 1937.

Cold Nuclear Transmutations
Light Atomic Nuclei Binding Energy

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Several authors predict that α particle structures could be present in atomic nuclei. Convincing arguments of such structures are provided by systematics of the binding energies of the even-even nuclei with equal number of protons and neutrons. In that hypothesis, it is necessary to consider the binding energy of α particle as well as the binding energy between several α particles in order to determine the binding energy of a given nucleus.

The kind of binding energy existing within each α particle is a first point to consider. How to relate that binding energy to the deuterium binding energy, as well as to the tritium and He3 ones as these exist before the α particle is constituted? Also, could these structures be found within the nucleus as substructures linking the nucleons of one α particle with the nucleons of another α particle?

It will be shown that the hypothesis of α structures in the n-α nuclei can indeed describe the binding energy systematics. In such an approach the system in its ground state behaves like a crystal, with stationary configuration and shape and with defined bond values between the various α particles. The examples provided are O16, Ne20, Mg24, Si28, S32, Ar36 and Ca40.

The hypothesis I develop founds its background in the structure of neutron/proton as well as α particle I propose in my document posted on the internet one finds under www.philippehatt.com
According to that hypothesis the nuclei of the various elements are constituted out of α particles and other nucleons grouped in order to form sub nuclei bound together by four types of bonds called NN, NP, NNP, NPP.

The kinship which will be demonstrated between the binding energy distribution within the various nuclei is very important for LENR purposes, first because the difference between binding energies of the elements at the beginning and at the end of the LENR process determines the energy released, and second and more important because one can follow the shift between these binding energy distributions during the LENR process.

My purpose is not about looking for a new model of atomic structures. It is the reason I have favored a unidimensional approach trying to breakdown the binding energy value of each element and its isotopes in several clusters indicated above. As these clusters are 3 D structures the global structures are also 3 D, my binding energy approach looking only at unidimensional MeV values.

Modeling & Simulation of a Gas Discharge LENR Prototype

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Experimental results from a stainless-steel LENR prototype reactor in a large thermal mass Seebeck calorimeter are modeled to accurately simulate experimental results. The well-known SPICE simulator is used for this work, where thermal properties of the apparatus are converted to lumped electrical circuits for simulation. Lumped electrical analogues for thermal components allow well developed electrical simulation technologies to quickly solve time domain thermal problems. Once the thermal model for a system is extracted, the simulation is accurate enough to detect possible experimental errors and inconsistencies. In addition, the unknown excess heat can be readily de-embedded from the typically long time constant of the calorimeter, enabling better time alignment of the excess heat response to the inputs that may have been the proximate cause for the effect.

XRD and XAFS Analyses for Metal Nanocomposites Used in Anomalous Heat Effect Experiments

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Anomalous heat effect (AHE) has recently been reported to be well reproducible in a series of collaborative experiments performed at elevated temperatures 200 ~ 350℃ using metal nanocomposites and hydrogen isotope gas [1 - 5]. A variety of samples were studied and AHE was found dependent on samples. For example, a remarkable AHE was observed for PNZ6 with a composition of $Pd_{0.032}Ni_{0.318}Zr_{0.65}O_{0.24}$. However, no AHE was observed for Pd/TMPS-4R in which Pd nano-particles with sizes ~4nm were included in the pores of the mesoporous silica matrix TMPS-4R.

In this paper, structural changes of PNZ6 and Pd/TMPS-4R with increasing temperature under hydrogen atmosphere were studied by in-situ XRD (X-ray diffraction) and XAFS (X ray absorption fine structure) analyses using facilities of Aichi Synchrotron Radiation Center. The analysed PNZ6 and Pd/TMPS-4R samples were a part of the materials that were used for the heat evolution experiments at Kobe University [5] and Tohoku University[2,4], respectively.

The in-situ XRD analyses were performed at 15keV under hydrogen atmosphere of ~ 0.4MPa, while raising temperature from room temperature (RT) up to ~600℃. XAFS profiles for K-edge Ni and K-edge Pd were taken under flowing hydrogen at 100 cc/min, while raising temperature from RT up to ~ 600 ℃.

For PNZ6, following results were obtained: i) before hydrogen exposure, PNZ6 dominantly consisted of $NiZr_2$ and ZrO_2, ii) after hydrogen exposure, the peak from $NiZr_2$ was divided into two peaks at 120℃, suggesting the formation of two hydride phases $NiZr_2H_{\sim1}$ and $NiZr_2H_{\sim5}$, iii) at 200 ~ 300 ℃, PNZ6 dominantly consisted of $NiZr_2H_{\sim5}$ and ZrO_2, iv) at 400℃, the formation of ZrH_2 started, v) at temperatures higher than 500℃, ZrH_2 and $Ni_{10}Zr_7H_6$ formed with a decomposition of $NiZr_2$.

The XAFS data were qualitatively consistent with the XRD results. From the Pd- and Ni- K edge XAFS data, it was suggested that nano-scale metallic Pd-Ni alloy particles exist in the mixed matrix of $NiZr_2$ and ZrO_2 even just after the partial oxidation treatment.

It was inferred that nano-scale Ni-Pd alloy particles enhance kinematics of hydrogen absorption and desorption of $NiZr_2$ which have a high hydrogen storage capacity. The remarkable AHE observed in PNZ6 may be correlated with such complex structure of nanoscale Ni-Pd alloy particles dispersed in a mixed matrix of highly hydrogen absorptive $NiZr_2$ and hydrogen inactive ZrO_2.

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Fabrication, Characterization, and Evaluation of Palladium-Boron Alloys Used in LENR Experiments

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The reproducibility of energy generation from heavy water electrolysis or the Fleischmann-Pons Effect (FPE) depends markedly on the source of the palladium metal used as the cathode. Based on years of research, two sources of palladium materials yielding good reproducible excess enthalpy effects have been identified: (1) palladium-boron materials, and (2) palladium materials prepared by co-deposition method. A common feature for both these methods is that they yield palladium that is free of oxygen as an impurity. This paper deals with the fabrication, characterization, and evaluation of palladium-boron alloys, which have produced excess enthalpy in nearly every experiment [1-2]. Two U.S. Patents have been granted for these materials [3-4].

Palladium has a Face Centered Cubic (FCC) structure with properties akin to gold, i.e., soft, ductile, and resistance to corrosion. The intrinsic hardness and tensile strength of Pd are too low for many applications. The addition of boron to palladium within solubility limit creates two FCC phases with different lattice parameters, one phase being distributed as fine particles within the other phase. The creation of two face centered cubic phases makes the material harder and less susceptible to cracking. That is attractive for some applications. In particular, it is the likely explanation for reproducible energy generation. It is interesting to note that palladium is not tarnished by dry or moist air at room temperature, but at about 600 ^{o}C a thin oxide film forms in air. Above 800 ^{o}C, the superficial oxide decomposes, leaving a clean metal surface. Some oxide formation occurs again above 1000 ^{o}C.

Another beneficial effect of the added boron is that it minimizes the activity of dissolved oxygen in the palladium by converting it to B_2O_3 during processing. The low density B_2O_3 floats to the surface, and is removed during the molten phase of the palladium-boron alloy preparation. The focus of this paper will be to investigate the excess enthalpy production of various compositions of boron in palladium within the solubility limit, including effect of loading of deuterium on grain sizes, developed by annealing for different times at different temperatures, and the extent of cold deformation. Since the mechanical and many other properties of palladium depend on purity, elemental analyses and x-ray diffraction studies will also be presented.

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Anomalous Heat Effects Induced by Metal Nanocomposites and Hydrogen Gas

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Collaborative research between Technova Inc., Nissan Motor Co. Ltd., Kobe Univ., Kyushu Univ., Nagoya Univ. and Tohoku Univ. had been performed for two years, which started in October 2015. In this collaboration work, a new highly accurate oil mass-flow calorimetry system was developed at Tohoku University [1] to replicate anomalous heat generation experiments reported by A. Kitamura and A. Takahashi et al [2]. This system was designed to improve the performance of the already existing flow calorimetry system at Kobe University.

In this paper, we describe evidence of anomalous heat effects mainly obtained from experiments at our laboratory in Tohoku University. Excess energy experiments were done using nano-sized metal composite with H_2 or D_2 gas. Main results at our laboratory are as follows.

1) Experiments using CNZ($Cu_1Ni_7Zr_{15}$-O_x) with H_2, PNZ($Pd_1Ni_7Zr_{15}$-O_x) with D_2, CNS (Cu_1Ni_{10}/SiO2) with H_2 and PSn1(Pd/SiO2) with D_2 were performed. Anomalous excess heat generations were observed for all the samples at elevated temperature (150℃-350℃), except for the Pd nanoparticles embedded in mesoporous SiO_2 (PSn1).
2) The amount of anomalous heat generation per hydrogen atom ranged from 10eV/H or D to 100eV/H or D. Note that these values were obtained using the number of hydrogen atoms absorbed into the metal; not the number of consumed hydrogen atoms.
3) The released energy is very difficult to explain by known chemical processes only.
4) Coincident burst-like increase events of the pressure of reaction chamber and gas temperature, which suggested sudden energy releases in the reaction chamber, were observed many times for an experiment using the CNZ type sample with H_2 gas.
5) These burst-like events were replicated during the experiment using the same CNZ type sample.
6) Excess heat experiments using the same material at Kobe and Tohoku Universities showed similar experimental results. Qualitative reproducibility between Kobe and Tohoku experiments was good.

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The Structured Atom Model - SAM

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The Structured Atom Model postulates that the nucleus has a precise, fixed, geometric structure based on two of the platonic solids, the tetrahedron and icosahedron. The nucleus grows predictably and its structure determines the properties of the elements which in turn defines the organization and periodicity of the periodic table of elements (PTE). The larger elements are built from clusters of 12 nucleons in the shape of an icosahedron. These clusters connect with each other in a tree-like manner and split into branches, doubling with each new set of branches.

Over 100 years of searching - For over a century, science has been in search of the structure of the atomic nucleus. In the book "Models of the Atomic Nucleus"[1], Norman D Cook provides a comprehensive overview of more than 30 atomic models each of which provides a partial understanding. However they are largely in conflict with each other and none of them adequately describes a significant portion of the observed properties of the elements.

Key Principles – The SAM was created by applying key principles found through observing nature – a) electron/proton duality, b) dense spherical packing, c) and the symmetry and stability of the tetrahedron and icosahedron.

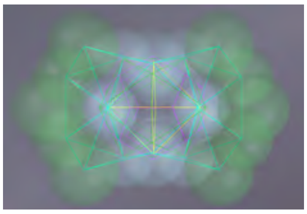
Initial research was to determine what structures can be built by putting spheres together, which of these structures are stable, and how can a structure continue to grow and remain stable. But most importantly the resulting structures were compared to the PTE and only structures that mimicked properties of the elements were followed. The result is that SAM can explain many of the properties of the elements – valence, nuclear spin, neutron/proton ratio, stability of isotopes, and much more.

The New Neutron - It is well known a neutron outside of the nucleus is unstable, it decays within 15 minutes into a proton, electron and anti-neutrino. The SAM postulates that neutrons do not exist as unique fundamental particles, but instead the SAM redefines neutrons as "nuclear electrons" that are shared between protons. The protons create the structure of the nucleus and the nuclear electrons are the glue that hold the protons together.

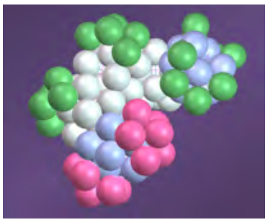
Explaining LENR - More and more evidence shows that LENR reactions occur on the earth all the time in biology, meteorology, geology and more – chickens change potassium into calcium, lightning makes carbon-14 from nitrogen-14, veins of quartz, silver and gold are found within solid rock. The SAM demonstrates that many of these phenomena are the result of clusters of nucleons being broken off of or added to other atoms. For example: A carbon and oxygen fuze together to form silicon-28.

The SAM points out there are two distinct different types of nuclear fission reactions. High energy reactions create neutrons and gamma rays, whereas LENR reactions are a fusion process of clusters and do not involve the creation of new 'neutrons'. This explains why there are no gamma rays in LENR reactions but there is still an excess of heat.

Magnesium-24



Neon-22



Strontium-86

Search for γ–ray radiation in NiCuZr nano-metals and H_2 gas system generating large excess heat

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Much work on anomalous excess heat generation in the Ni-H system has been made since the early days of Cold Fusion study, which began with Pd-D system by heavy water and Pd electrode. Recent studies including our cooperative experiments [1,2] have made it clear that hydrogen gas absorption (or discharge) by Ni-containing complex nano-metals produces large thermal energy far beyond that of chemical reaction. However, the origin of this excess heat generation has not been known, yet. Focardi et al. reported some radiations from the Ni-H system including a discrete γ-ray emission as evidence on nuclear reaction [3]. In the present work, we have searched for γ-ray emissions from our system possibly focusing on the Ni + p reaction.

Gamma rays were detected in parallel with precise measurement of heat generation from our system using H_2 gas and CNZ6s sample (the sample with CuNiZr composition ratio same as CNZ5s reported in [1]): averaged excess power was about 2.1 W and total thermal energy 5.3 MJ/mol-H. A Ge detector (ORTEC) was placed outside the wall of chamber with its front face at 5 cm from the wall and γ rays up to 2.7 MeV were measured.

Figure 1 shows examples of the measured γ-ray spectra. The upper one corresponds to the background measurement and the lower one to the foreground during the heat generation. In the case of 1 MeV energy release by a reaction, its reaction rate should be 6.24×10^{12} reactions/sec for 1 W output. Counting rates (Counts/sec) of prominent peaks in the BG spectrum are 0.253 (609 keV; ^{214}Bi), 0.18 (1461 keV; ^{40}K) and 0.047 (2614 keV; ^{208}Tl); far below the reaction rate of 1 W. Thus, if discrete γ rays were released in a reaction generating the heat, they should be observed with good statistics.

In Fig. 1, there are many discrete γ rays in the lower spectrum, as you can see. However, all the γ-ray peaks agree with those seen in the BG spectrum. Thus the comparison of the spectra simply indicates that no discrete γ rays are emitted in the reaction which produces anomalous excess heat.

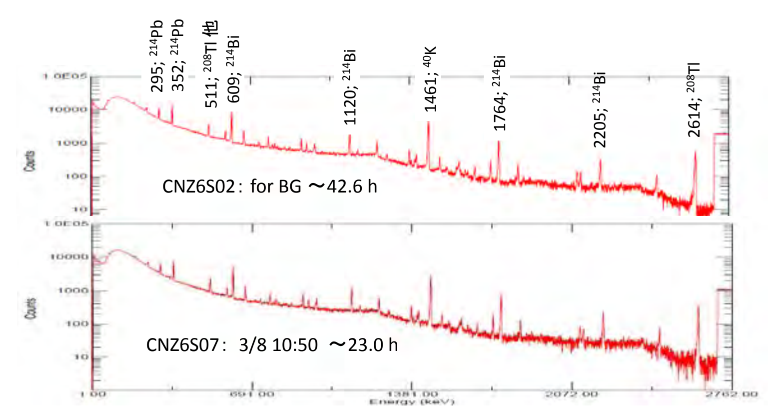

Fig. 1. Gamma-ray spectra for background (upper) and foreground (lower).

We will report the results based on a more detailed analysis, and discuss on possible reactions in the NiCuZr composite nano-metals with H_2 gas.

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LEAP: The LENRIA Experiment and Analysis Program

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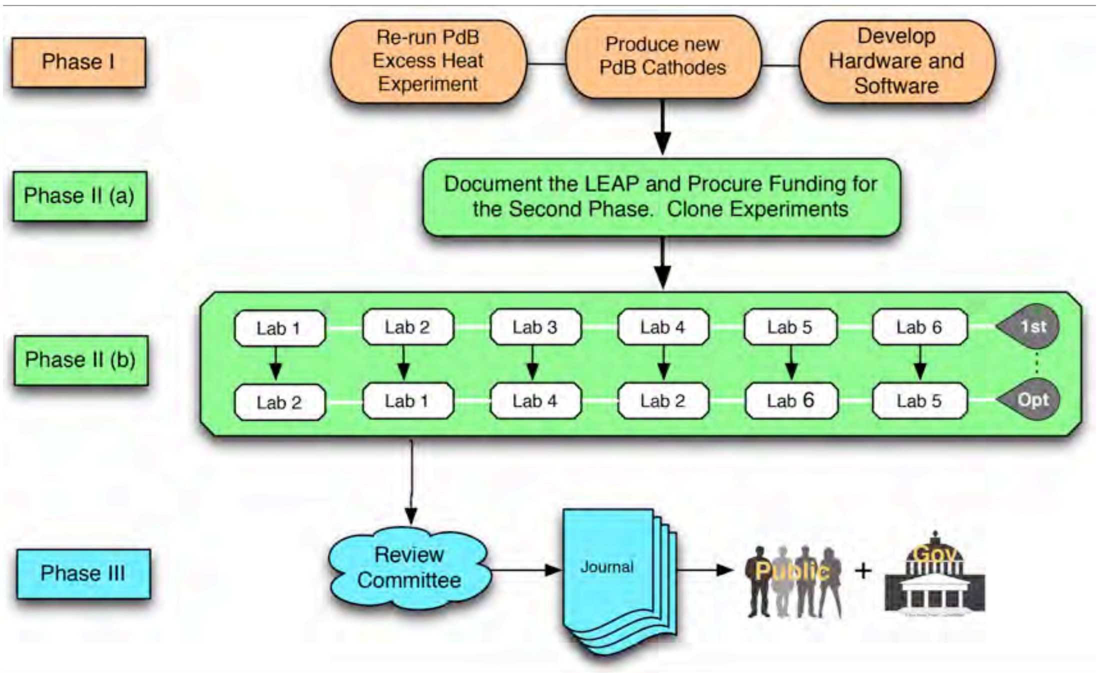
We have planned and are preparing for a multi-laboratory experimental program aimed at reversing the negative scientific and public perceptions about the legitimacy and promise of LENR.

There has not been broad scientific acceptance of the existence of LENR. This is due to many factors. The LEAP program is designed to reduce the number of variables associated with achieving LENR reproducibility by delivering a turnkey experiment to a group of well-regarded laboratories and experimentalists. Institutionalizing the engineering, construction, programming, testing and materials phases of the experiments is expected to reduce the introduction of unknowns, while permitting participants to focus on operating and vetting the experimental regime, and reporting their results.

The multi-lab nature and simultaneity of the experiments and reporting for the LEAP program are designed to improve the environment for debate and analysis of the experimental data and to draw attention to the field. The best outcome of the LEAP program would be to achieve demonstrable proof of the LENR phenomenon that is sufficient to begin to change the perception of the scientific establishment, of 'very important people,' and the public.

The flow diagram for the LEAP follows. The first phase consists of the preparation and qualification activities. Phase II requires the involvement of major international laboratories. Phase III will be comprised of review and publication activities for a scientific journal, along with a media campaign. Currently, we are well into the three activities in the first phase of the LEAP. The status of work on the program will be detailed. Comments on both the strategy and the details of the LEAP are solicited.



Direct Joule Heating of D-Loaded Bulk Pd Plates in Vacuum

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A gas-phase experimental research in quest of condensed-matter fusion is underway by using multilayered deuterium-containing Pd plates. We in particular directly apply a bias voltage across the Pd sample to provide a current injection through Pd, to stimulate the nuclear reaction by Joule heating, also anticipating strong electrodiffusion or electromigration, in addition to the conventional deuterium diffusion induced by pressure/mass-concentration and thermal gradients.

Our experimental setup is a gas-phase, clustered reactor system [1,2]. A high-resolution small-amu quadrupole mass spectrometer, a gas proportional neutron detector, and a Geiger-Mueller detector for α, β, and γ rays are equipped to the facility. We first annealed a bulk Pd plate in an external furnace to degrease the surface. A Au film was then deposited on one side of the Pd plate, as a low-contact-resistance electrode as well as a capping layer to induce single-directional deuterium diffusion and desorption for the ease of analyses. The Pd plate absorbed deuterium asymptotically to the equilibrium, in a D_2 ambient of 760 Torr at room temperature. Electric current was then injected through a W needle contacted the Au-deposited surface of the Pd plate.

Figure 1 shows our typical experimental result. There are points of palladium-temperature increase with accelerations, despite the decrease in input power. Because the observed system is a deuterium-desorption process due to the palladium-temperature increase caused by the input power, the temperature should have relatively decreased based on the known chemical phenomena, since gas-desorption processes are endothermic. We did not observe such a rapid increase of temperature in the reference control runs without deuterium loading. Furthermore, even when the input power was smaller for the run wit deuterium loading than tha for the control withou deuterium, the temperatur attained with deuterium wa higher despite containing a endothermic process c deuterium desorption. Th temporal behavior of the hea generation is thus unable t be explained by know chemical processes. We hav furthermore observed neutro signal peaks at timing corresponding to th accelerated temperature increases.

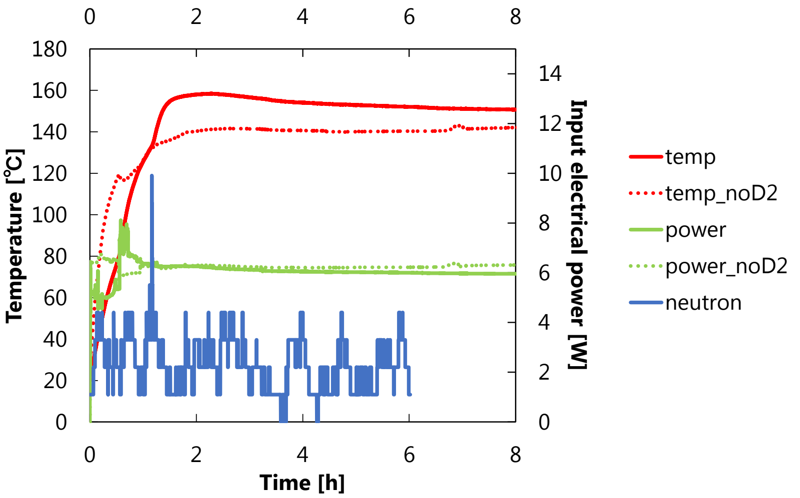

Fig. 1 Time evolution of Pd temperature and neutron signal.

We thank Hiroshi Sugiura for his support on the experimental equipment. We also thank for the technical advices by Kai Masuda, Tadahiko Mizuno (radial-ray detection), Yasuhiro Iwamura (Pd pretreatment), Akira Kitamura and Akito Takahashi (mass spectroscopy). This work was partially supported by the Thermal & Electric Energy Technology Foundation.

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Stimulation of LENR in Hydroborate Minerals Under the Action of Distant High-Frequency Thermal Waves

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It is well known that for realization of LENR in solids it is necessary, at least, the satisfaction of two threshold conditions: a) high level of loading of such solids by hydrogen isotopes; b) presence of optimal nonstationary structural elements in the volume of these solids which essentially (by many orders) increase the probability of LENR.

Such requirements lead to the the necessity of complex, long and costly technological operations to load of working media by hydrogen and the subsequent formation of conditions for low-energy fusion at low energy.

This report presents the results of a study of natural objects (hydroborate minerals) th**a**t automatically satisfy both these requirements without additional actions and processing. These minerals contain (consist of) hydrogen and boron, do not require pre-loading, and are a very effective medium for one of the most attractive nuclear reactions $B^{11} + p = 3He^4 + \Delta E$ with large release of energy $\Delta E = 8.7\,MeV$ and practically full absence of induced radioactivity.

At standard conditions of a pair interaction of free nuclei, this reaction has a maximal cross-section under relative energy of colliding particles $T_{pB^{11}} = 675\,KeV$. This is large energy and usually, to obtain it, highly-current ionic accelerators are needed.

Our research is fundamentally different and does not require any special preliminary operations.

In our experiments, we use a special undamped thermal shock waves [1-4] of small amplitude to form a special secondary acoustic intracrystalline shock waves. We discovered and investigated these undamped thermal waves at a great distance in numerous successful experiments [5,6]. Action of these waves lead to formation of coherent correlated states of protons that are situated (localized) in intracrystalline nonstationary potential wells deformable under the action of the waves. In these states, the proton energy fluctuation in usual cold (room temperature) minerals can reaches 30…50 keV and more [7-10].

During the test experiments with using of external distant source of undamped temperature waves we have confirmed the correctness of our concept and registered numerous fast alpha-particles with maximal energy about $E_{\max} \approx 2.9\,MeV$ accompanying these reactions.

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Electron mediated nuclear chain reactions

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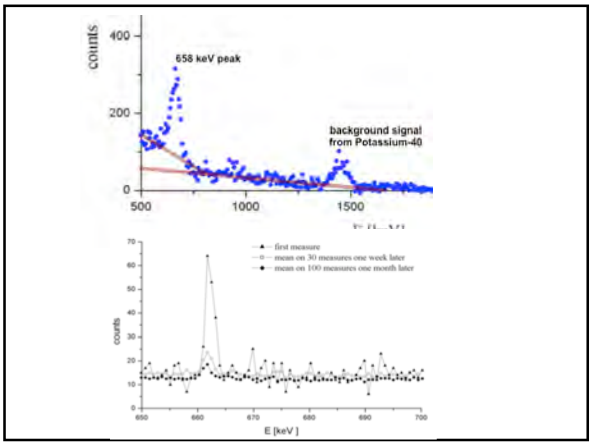
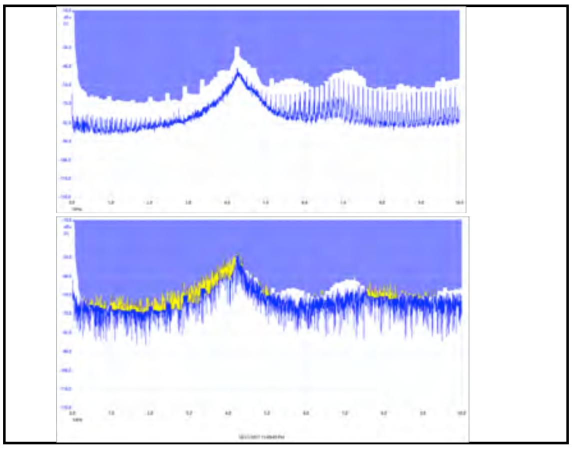
Up to now, only neutron-mediated chain reaction of heavy nuclei has been conceptualized and investigated, which is the basis of all current nuclear energy production. Here, we introduce the concept of electron mediated reactions. We propose that (i) This class of nuclear reaction is initiated by the nuclear capture of energetic electrons; and (ii) The reaction may generate a higher number of energetic electrons as the output.

Upon the re-evaluation of relevant past experimental results [2, 3], we find that the reaction signatures are compatible with the herein proposed reaction process. Furthermore, in a previous publication [1], we have investigated ^{58}Ni containing alloys and ^{6}Li -^{7}Li mixtures as possible fuels for electron mediated nuclear chain reactions and shown experimental evidence for an exothermic nuclear reaction in which the observed experimental details are also consistent with the herein proposed process. To understand the aforementioned experiments, possible electron mediated reactions in metallic solid states are discussed, which are fuelled by either nickel or lithium. We believe in this process the energetic electron capture and multiplication steps are indispensable to interpret experimental results.

In the talk, complementing the theoretic discussion, we will present experimental evidence from relevant experiments in literature, as well as our own experiments， which implies the possibility of sustainable energy production from metallic nickel or lithium.





Left figure: Measured Gamma signature of the ^{58}Ni reaction [2]; 500-2000 keV spectrum (top) and precise measurement of the gama emission peak (bottom)
Right figure: Measured RF signature of the ^{58}Ni reaction in the 0-10 MHz range [1]; background signal (top) versus ongoing reaction (bottom)

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Building & Testing a High Temperature Seebeck Calorimeter

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A high temperature Seebeck calorimeter capable of operating at 200-300C was built and tested. The testing used a glow discharge tube containing plated palladium on the side walls and a Molybdenum central anode. Running with deuterium gas and high voltages demonstrated excess thermal power at levels of 5-10 watts but no excess power was observed when natural abundance hydrogen was used. In addition to the normal Seebeck measurements, excess power was also observed using back-off power measurements of the enclosure heater containing the Seebeck. A resistive control heater was used to verify the system.

Resonant Surface Capture Model

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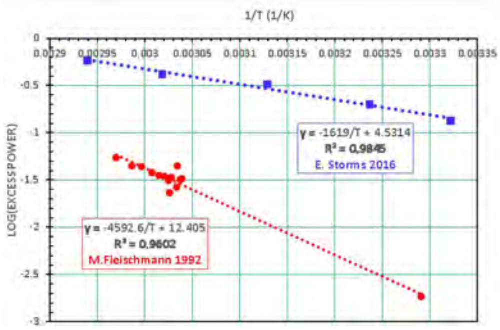
Concept: The essence of resonance is to put the peak of wave function at the nuclear edge; thus, the deuteron would deliver a neutron to the surface of target nucleus; then, cause the capture of neutron by the target nucleus. When this resonance is at very low energy, the resonant elastic scattering (diffusion process) is maximized; and the consequent capture (excess heat) is maximized as well. Both are featured by an exponential factor, $\boldsymbol{Exp}[-\frac{\boldsymbol{E_0}}{\boldsymbol{T}}]$ which leads to the straight line in temperature (T) dependence of excess heat in semi-logarithmic plot (Fig.1). The blue straight line was first published by E. Storms, later derived by M. Miles using Eyring theory, and now reconfirmed by Fleischmann and Pons' 1992 data (red line) and Tsinghua Univ. data (see another abstract). Indeed, the straight line implies this resonant surface capture model.

Equations for Average Rate of Diffusion and Excess Heat:

$$< \sigma_{Elastic} v > = \left(\frac{\mu}{2\pi k_B T}\right)^{\frac{3}{2}} \int_0^{\infty} \left(\frac{\pi}{k^2}\frac{4}{W^2+1}\right) \cdot v \cdot Exp\left[-\frac{\mu v^2}{2k_B T}\right] \cdot 4\pi v^2 dv \propto Exp\left[-\frac{E_0}{T}\right]. \quad (1)$$

$$< \sigma_{EX} v > = \left(\frac{\mu}{2\pi k_B T}\right)^{\frac{3}{2}} \int_0^{\infty} \left(\frac{\pi}{k^2}\frac{4}{W^2+1}\right) \left|\int \Psi_f H_{int} \Psi_i \, d\tau\right|^2 \cdot v \cdot Exp\left[-\frac{\mu v^2}{2k_B T}\right] 4\pi v^2 dv \propto Exp[-\frac{E_0}{T}]. \quad (2)$$

Here, $\Psi_i = W F_0 + G_0$, G_0 $(F_0)$is an exponentially increasing(decreasing) function near the nuclear surface, and resonance appears when $W \leq 1$, $W^2 \equiv (\theta^2 w)^2 = \left(\frac{Exp\left[\frac{2\pi}{k\,a_c}\right]-1}{2\pi} \cdot w\right)^2$; $(1/\theta)^2$is the Gamow penetration factor; E_0 is the resonance energy assumed at low energy which is close to the activation energy of diffusion coefficient, E_a.



Calculation: The average rates in (1) and (2) are calculated based on the H. A. Bethe's solar energy model (1938) and the J. R. Oppenheimer's deuteron stripping reaction model (1935). It shows:

(1)Width of this resonance is proportional to 1/Log[θ] instead of $(1/\theta)^2$; therefore, the average over Maxwell distribution is not negligible even if the resonance energy is as low as the thermal energy;

(2)Weak gamma emission of Pd cathode wires is from the slightly excited target nucleus during this stripping reaction because the energetic charged particle carries away most of the reaction energy as first proposed by T. Passell (2015).

(3)NAE or **NAZ** is created by this resonant elastic diffusion process, which generates the mother state of nuclear transition. This transition probability is maximized by this resonance as well. A deuterium flux is necessary to create this mother state in terms of resonant elastic scattering.

(4)Positive feed-back effect in temperature is a result of this exponential temperature dependence $\boldsymbol{Exp}[-\frac{\boldsymbol{E_0}}{\boldsymbol{T}}]$. The micro-crater on Pd surface is the evidence of this effect;

New Finding: Big difference between low energy resonance and usual resonance caused by the big difference in the behaviour of θ^2. For d+Li6, resonance at 2000 K, $\theta^2 \sim 10^{4090}$ and varies rapidly with energy; then, resonance appears at $\boldsymbol{W^2} \leq \boldsymbol{1}$ instead of $\boldsymbol{W^2} = \boldsymbol{0}$. It makes the elastic scattering cross-section **step-wise** and makes the reaction cross-section **peak-wise**, at $E \sim E_0$ (in contrast, for d+T resonance at 100 keV, θ^2=13.3 and varies slowly, and resonance may appear at $\boldsymbol{W^2} = \boldsymbol{0}$).

Prediction: More fuels are available for this resonant surface capture reaction provided that the target nucleus has an energy level very close to the thermal energy (e.g. d+Li6, p+B10, etc.). High electric charge number Z is no longer a problem. The best candidate would be the gadolinium (**Gd**), which has the largest capture cross-section of thermal neutron.

Correlation and cold fusion

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To improve collective understanding of cold fusion, we must recognize and understand the history. Cold fusion was called, by John R. Huizenga,, "*Cold Fusion: The Scientific Fiasco of the Century.*" He was correct. Gary Taubes titled his book, prominently, *Bad Science,* and then in much smaller text, *The Short Life and Weird Times of Cold Fusion.* Taubes was a writer facing no income until he finished the book. The 1989 DoE panel was charged with finding a quick answer in a field where quick answers did not exist.

What the Panel reported was not wrong, in that the evidence at that point was not conclusive. They correctly suggested further research. Taubes, in his rush to complete, did not consider Miles' heat/helium work.

Just as premature rejection led to a widespread belief that cold fusion was found to be a mistake "long ago," so too, reaction to that belief damaged our own work. We believed that it was necessary to produce 'better' results to convince skeptics, "better" usually meaning substantial and reliable heat. Yet the most significant missing evidence from the original work was not heat, it was the reaction product, and especially a correlated nuclear product.

Until this shifts, it is a confirmed characteristic of cold fusion that heat is erratic, not reliable. Steady, reliable results may be a sign of possible artifact … or possible fraud. That may change some day, but the tragedy is that the intense search for "better" results damaged the scientific study of the known effect. Miles showed the way in 1991 with heat/helium.. This considered astonishing by Huizenga "if confirmed," did not depend at all on reliability. It used the variability in heat as "self-control."

There were shortcomings in the Miles work, some of them addressed later, and all addressable by replication with more data from more samples, with increased precision and clearly-defined protocols. Basic confirmation of Miles took many years, and the best result so far, an individual test instead of a substantial series, still had an estimated precision of ten percent.

In the rush to confirm cold fusion, to vindicate Pons and Fleischmann, we lost the scientific method, in which one seeks to prove one's own ideas *wrong*, diligently.

Pons and Fleischmann had an idea that the effect they discovered was a bulk effect. If the reaction were taking place in the bulk, and if helium were the product, it would remain in the bulk, yet when the bulk was studied, helium was not found there. So they failed to release the promised helium analysis results from Johnson-Matthey, and deprecated helium measurement as too expensive, hence their heat-after-death work in France did not apparently include helium measurements. The net result was the waste of millions of dollars, and years of delay.

We need the mainstream. Running with one leg tied until we have communicated the realities of cold fusion to the scientific world, we need the interest of genuine skeptics, those who will actually investigate and sanely criticize what is claimed. That interplay is necessary for science.

We will explore the history (including recent), draw practical conclusions, and discover possibilities.

The author expresses gratitude for the long-term personal encouragement and support of Edmund Storms and Michael McKubre, without whom I would never have undertaken this work.

Photocatalytic hydrogen evolution and induced transmutation of potassium to calcium via low-energy nuclear reaction (LENR) driven by visible light

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Modern physics studies show that element transmutation can take place either by natural process or artificial process. Nevertheless, inducing transmutation reaction via colliding method requires highly energy accelerator equipment with vast power supply and cost. Besides, a large number of experiments certified that transmutation could be initiated in “mild” reactive systems under certain circumstances, like in metabolism processes of vegetal and animal organisms over the past two centuries. To investigate transmutation in biological systems, Kervran et al. investigated potassium and calcium content variation during the growth of 840 seeds and 403 sprouts. They proposed potassium might transmute into calcium during the process of seeds growing, which could be represented in reaction formula: $^{39}K + {}^{1}p = {}^{40}Ca + E$ [1]. Up to now, there is no unified point of view on the mechanism of elemental transmutations in “mild” reactive systems. Unveiling that mystery is extremely meaningful for understanding how life evolution and surviving on earth, as well as providing safer and low-cost way to make use of nucleus energy.

In this work, we fulfilled the transmutation of potassium element to calcium during photochemical reaction of hydrogen evolution (HER). Photochemical HER reaction system is a bionic system which simulates the behaviour of plants in nature to absorb and convert solar energy for hydrogen production. Inspired by a recent discovery of our group, the deuterium and helium were generated from protons by LENR in that system [2], potassium was chosen as the target transmutation element in this work, taking into account the essential roles of potassium and calcium in biological bodies. It is interesting to find that the concentration of calcium elements increased during the photochemical HER reaction in the presence of potassium. The results indicated that the increasing of calcium elements might be closely related to H atoms with electro-negativity hydrogen (H-) generated in reaction system. We also identified the similar transmutation could be achieved by negativity hydrogen in $NaBH_4$ under dark conditions.

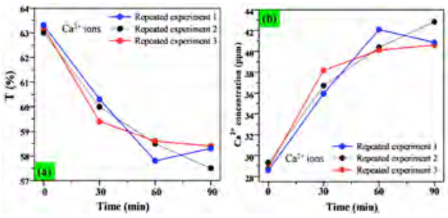

Fig. 1 Colorimetric analysis results of photochemical HER system (adding K_2PtCl_6) (a) Transmittance at 650 nm over time (b) Ca^{2+} ions concentration over time

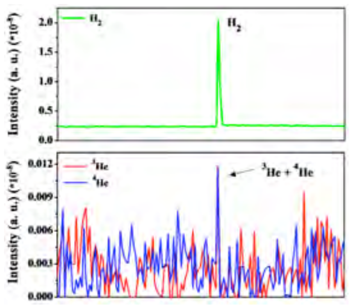

Fig. 2 Mass spectra of gases evolved from Repeated experiment

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(http://www.jmcchina.org/ch/reader/create_pdf.aspx?file_no=20170501&flag=1&journal_id=fzch&year_id=2017)

Light Hydrogen LENR in Copper Alloys

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Low Energy Nuclear Reactions (LENR) produced in dilute copper alloys containing light hydrogen will be described here. This system was selected because of the low cost of its constituents, ease of processing, and similarity to other, much more expensive, materials that have been extensively reported in the literature to produce nuclear heat. The focus here is on heat, with an excursion into thermal radiation, rather than on reaction products that are difficult and expensive to investigate.

A fundamental basis, and advantage, of LENR over other nuclear energy developments is the production of substantial power WITHOUT dangerous by-products. So this research has been guided by the well-known nuclear reactions between the stable isotopes of hydrogen and the stable isotopes of boron and lithium that produce helium-four and roughly eight MeV of energy. Strong interatomic forces in metals, as affected by solutes and the cloud of free electrons must also be important in LENR. If young's modulus is used as a stand-in for those forces they are much smaller in copper than nickel or palladium, but still substantially in excess of one million atmospheres.

The effort has been divided into three phases, each involving significantly different processes, complexity and instrumentation:

(1) **Simple addition of hydrogen to a copper-based alloy.**
Hydrogen was loaded into copper-lithium-boron alloys at elevated temperature (400–900°C) and pressure (about 10 atmospheres). The encapsulated specimens were quenched, and immediately inserted into a calorimeter to detect nuclear heat. That method showed little success. It is apparently too simple.

(2) **Low Q capacitors.**
Cells containing hydrogenated copper–lithium–boron alloy electrodes separated by a liquid dielectric containing fine graphite particles have been tested. A vacuum-insulated seebeck calorimeter was used. When the layers of copper alloy are alternately charged, electric currents are constrained to flow through the graphite particles at specific sites, resulting in microscopic variations of charge in the metal and localized electron flows. Note that most LENR experiments involve such charge mobility [1]. An example of this anomalous heat effect from a low Q capacitor was exhibited at ICCF-18 (University of Missouri, U.S.A.) [2]. That specimen showed a small (about 25 milliwatt, 9% of input), statistically significant (on a three sigma basis) excess heat. Results from a control specimen, devoid of hydrogen, are indistinguishable from the calibration data of the calorimeter. Other examples using the Low-Q capacitor method will be presented. Infrared images of electrodes producing anomalous heat by this method are being taken.

(3) **Substantial reduction of input power to produce a self-sustaining demonstration.**

Phases (2) and (3) will be discussed. Other scientists (especially those with limited resources), are encouraged to participate in these important efforts.

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The Fleischmann-Pons heat and ancillary effects.
What do we know, and why? How might we proceed?

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After almost 30 years of studying seemingly anomalous nuclear effects in metal hydride systems what can we say that we have learned with high-level confidence? For some of us it has been a nearly full-time journey; for a rare few nearly fully-funded. After this time and effort what is it that we can assert and defend about our new knowledge of nuclear reactions in condensed matter? These questions are subjective and I will focus my answers on what I have learned by direct experiment and analysis, and from the experience of a few close colleagues – mostly ENEA (Italy), Energetics (Israel), MIT and various Navy Labs around the US.

One must seek scientific truth *via* correlation. Isolated "facts" are rightly called "anomalies". These are useful in alerting the world to the presence of potential novelty but are not particularly useful in themselves and I have resisted characterizing our field as "anomalous". Anomalies exist to be explained or rejected – in either case forsaken as anomalies. At one point I recommended not accepting papers for presentation at one of our conferences unless more than one variable was measured and a correlation shown between them. In our work at SRI, initially the correlation sought was excess heat and loading. Under EPRI sponsorship (and gentle duress) we searched diligently for correlation between excess heat and any plausible nuclear product: neutrons, gammas, X-rays or low energy gammas, betas, photo-radiographic evidence of any photons, tritium (indirectly) and (finally) helium-4 and helium-3.

This exercise of seeking multi-correlation is, however, exquisitely painstaking and, therefore expensive, requiring the physical presence of experts covering a wide range of specialized knowledge and specialized hardware. In FPHE experiments more subtle difficulties are added by the challenge (or impossibility) of optimizing experiments to satisfy the constraints of: electrochemistry, without which there is insufficient loading and apparently no effect; calorimetry, without which there is no believable effect to correlate; and whichever of the pantheon of potential nuclear products (not ash) that one strives to correlate. Obviously everyone except the experimenter would prefer the search for products in all plausible output channels, in real time, and *in situ.* But this is experimentally not possible at our present level of investment – and perhaps not at all unless the effect is made larger and triggerable. Gozzi *et al* [1] have reported a nuclear multi-correlation (X-ray, heat excess and helium-4 in the D/Pd system) but they were cautious in their interpretation and this work was not continued.

How might we proceed rationally? Nearly 30 year old anomalies should have grown to adult maturity and self-sustainability or been buried and forgotten. By various factors we have been heavily constrained from pursuing and accomplishing the one thing that would make anomalies go away: correlation, preferably multi-correlation. Correlation is one thing that can rapidly advance our research and cause. Practical reality is another – a working device even if only a toy, but with net gain and easily observed utility. The search for correlation would be vastly simplified by an ability to trigger the effect on demand thus permitting phased analysis. A working device demands even more - the capability to control the effect; the ability to turn it on/off, up/down. What indications do we have to encourage us and guide us to tread either of these paths?

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Observation of non-exponential decay of x-ray and γ lines from Co-57 on steel plates

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At ICCF20 we proposed an excitation transfer experiment [1] based on relativistic phonon-nuclear coupling [2]. The idea was to put a matched radioactive source on a metal plate, where the decay results in a nuclear excited state of an isotope present in the metal, and then stimulate with vibrations to transfer the nuclear excitation to other stable nuclei. Excitation transfer could result in spatial delocalization in the emission, in an angular anisotropy of the emission, or in other effects. An overview of the initial experimental effort was presented at ICCF20 [3].

We reported at the 2017 ISCMNS Asti workshop on a preliminary observation of non-exponential decay seen in the first excitation transfer experiment in May, where radioactive Co-57 (which decays to produce excited nuclear states in Fe-57) was evaporated on a steel plate [4]. Stimulation by MHz vibrations was not observed to produce a prompt response as had been hoped. Instead we saw a non-exponential decay of the Fe K_α and Fe-57 14.4 keV gamma peaks which resulted from mechanical stress associated with tightening clamps at the start of the experiment.

The current picture is that the stress results in dislocation movement in the steel, which primarily scatters but also generates high frequency phonons in the THz region, which theory suggests are much more effective in mediating excitation transfer. A dynamic delocalization of the source could result in a non-exponential decay effect, which is enhanced by transmission through a coarse aluminum mesh.

In this talk we describe non-exponential decay effects seen in some of the early experiments. In August we found that it was possible to induce the non-exponential decay effect using a thermal stimulation. Highlights of recent results and observations will be presented.

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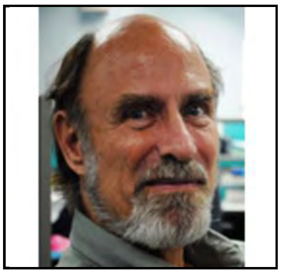

Nuclear-waste remediation with femto-atoms and femto-molecules

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The s-orbits of atomic electrons pass through the atoms' nuclear region in which the kinetic energy gained from the Coulomb potential of the nuclear and electron charges makes such electrons relativistic. The relativistic Schrodinger (Klein-Gordon or K-G) and Dirac equations predict deep electron orbits with radii in the femto-meter range; but, they do not predict how electrons can get there or what happens when/if they do. In prior papers, we have explored the nature of deep-orbit solutions of the relativistic equations [1-4] and of the resulting femto-atoms (and even femto-molecules) [5-7]. One prediction of this model, based on observations from successful cold fusion results and mentioned in several of the above references, is that of hard-radiation-free transmutation. An extension of this important feature is that of the relativistic long-range electromagnetic forces of the deep-orbit electrons [8,9] that can draw a femto-atom or molecule through a lattice to an excited or unstable nucleus.

The selective attraction of the mobile femto-atoms or molecules to radio-nuclides means that, not only transmutation products but, all radio-active materials in the vicinity are preferentially made to decay by multi-particle, but fast, processes. This ability to so neutralize such materials explains some of the outstanding questions about low-energy nuclear reaction (LENR) results, such as why characteristic decay products of observed transmutation products are not seen. It is also a means of further validating the electron deep-orbit model of cold fusion (CF). Presently, the model is only a single possible explanation of observations. If the substrate in a CF-active system is intentionally doped (with specific isotopes and radioactive elements), it should be possible to direct, and thereby determine and quantify details of, both the CF processes and the subsequent transmutation pathways and hard-radiation mitigation. This paper seeks to consolidate and expand our prior material on selective transmutation and nuclear-waste remediation to make suggestions for experimental testing of the proposed model.

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On the Oxidation of Palladium

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Palladium/zirconium alloys have frequently been used to produce nanoparticles with composite Pd/ZrO2 structures with crystallite length scales on the order of 10 nm. In the synthesis of these materials, the role of oxidation is critical. Here we review present knowledge found in literature on the conditions necessary for the oxidation of palladium via a diverse range of experiments.This is combined with recent thermogravimetric and x-ray diffraction experiments. Models for the oxidation of palladium are presented and this is then contextualized in terms of the formation of PdO/ZrO2 from PdZr starting alloys.

Excess Power Measurements For Palladium-Boron Cathodes

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One of the major goals of the U.S. Navy cold fusion program (1992-1995) was to produce our own palladium cathode materials at the Naval Research Laboratory (NRL). However, none of these Navy palladium metals and alloys were successful in producing the Fleischmann-Pons (F-P) excess power effect during the first two years. This all changed with the NRL preparation of palladium-boron (Pd-B) alloy cathodes in 1994. Seven out of eight experiments using these NRL Pd-B cathodes produced significant excess power in calorimetric studies at the Navy laboratory at China Lake, California (C/L). The one failure was related to a folded over metal region which acted as a long crack on the electrode surface. This success with Pd-B alloys made by NRL came too late to prevent the closure of the U.S. Navy cold fusion program in 1995, but these results are documented in a Navy report [1].

The author had the opportunity once again to work on cold fusion in 1997-1998 at the New Hydrogen Energy laboratory (NHE) in Sapporo, Japan. Three F-P Dewar calorimeters were available for this work, and a new Pd-B cathode from NRL was included in these experiments. Significant excess power for Pd-B was again observed [2]. The computer data from this experiment was also later carefully processed by Martin Fleischmann and published in a detailed NRL report [3]. The excess power was verified throughout most of this experiment and increased to nearly 10 watts during the boil-off of the cell contents. A significant new observation for this Pd-B cathode was the very early appearance of the excess power effect within the first two days of this experiment [3].

Last year (2017), this same Pd-B cathode was tested again using a different calorimeter at Ridgecrest, California (R/C). Excess power was observed, although the effect was considerably smaller than found at the NHE laboratory in 1998. Nevertheless, the excess power of 70 mW was clearly above the experimental calorimetric error of ±3 mW.

In summary, 9 out of 10 of my experiments using NRL Pd-B cathodes have produced excess power in six different calorimeters. Selected examples are shown in Table 1. The calorimetric results for all ten Pd-B experiments will be presented, and possible important properties of these Pd-B materials will be discussed. The effects of boron added to the palladium include a much greater hardness of the metal, a much slower rate of deuterium escaping from the cathode, the fact that boron acts as an oxygen getter, and that the Pd-B is a two-phase material. Two important unreported Pd-B experiments at NRL in 1995 will also be discussed.

Table1. Selected Examples of Pd-B Experiments.

Date	Location	Calorimeter	% B	Excess power (mW)
May, 1994	C/L	C/L-B	0.75	150
October, 1994	C/L	C/L-C	0.75	300
March, 1995	C/L	C/L-A	0.50	100
March, 1995	C/L	C/L-D	0.25	80
December, 1998	NHE	F-P	0.50	450
March, 2017	R/C	Copper-B	0.50	70

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Calorimetric Insights From Fleischmann Letters

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I received many letters from Martin Fleischmann over the time period of 1992 until about 2008 which were very helpful towards the understanding of the Fleischmann-Pons (F-P) Dewar cold fusion calorimetry. These letters are being converted to electronic form by Jed Rothwell to make them readily available to others interested in this topic [1]. Many more general topics relating to cold fusion were also discussed in these letters. My Fleischmann letters often focused on different calorimetry issues including the many errors in the 1989 publications by CalTech, MIT, and Harwell which were very influential in erroneously convincing most scientists that the reported cold fusion results were due to calorimetric errors.

Many types of calorimetry were considered before F-P settled on an open, isoperibolic system for their cold fusion experiments. The size of the calorimetric cell must be considered. If the cell is too large, then the effect of any excess power may not be detectable by the cell temperature measurements. If the cell is too small, then the changing electrolyte level due to electrolysis may cause large changes in the calorimetric cell constant. A properly designed calorimetric cell should contain between about 50 and 100 mL of electrolyte. Furthermore, the cell should be tall and narrow for proper stirring of the cell contents by the electrolysis gases. For example, CalTech used short and fat calorimetric cells where an electric stirrer was needed, and false statements were carelessly made by Lewis about stirring problems for the F-P cells. Harwell used large calorimeters up to 1000 mL in some experiments where any typical excess power would be impossible to detect by their cell temperature measurements.

Equations used to model the calorimetric system must include all possible energy transfers between the cell and its surroundings [2]. For example, the effect of temperature changes of the cell must involve the heat capacity of the cell as given by the differential power term, $P_{calor} = C_pMd(\Delta T)/dt$. Therefore, the F-P calorimetric analysis always involves the use of a differential equation. In one letter, Fleischmann provides a long, mathematical derivation to prove that there is never a steady state where $d(\Delta T)/dt = 0$ for open isoperibolic calorimeters. Many calorimetric publications, including CalTech, MIT and Harwell fail to include this important heat capacity term. Therefore, large negative excess powers have been reported when the cell temperature is increasing which have been confused with calorimetric errors. This neglect of the power being used to heat the cell contents is readily apparent in the Harwell publication.

Other topics include Fleischmann's various methods for obtaining cell constants accurate to five significant figures, the loss of D_2O due to evaporation, the re-fluxing of D_2O in the cell and gas exit tube, the use of the Stefan-Boltzmann constant for determining a minimum value for the cell constant, errors made by NHE in their analyses, and the fact that a changing excess power will always make it impossible to accurately calibrate a cell. These various topics all illustrate Fleischmann's remarkable abilities in the mathematical modelling and data analysis of cold fusion calorimetric cells as well as in many other areas of science [2].

1. See LENR-CANR, Fleischmann Letters.

2. M.H. Miles and M.C.H. McKubre in "Developments In Electrochemistry: Science Inspired by Martin Fleischmann", D. Pletcher, Z.- Q. Tian and D. Williams, Editors, Wiley, West Sussex, U.K., pp. 245-260, 2014 (see also the other book chapters).

No Steady State For Open Isoperibolic Calorimetry

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A continuing controversy for electrochemical open isoperibolic calorimetry is whether or not a steady state exists for the cell temperature (T) where $dT/dt = 0$. Fleischmann has provided a mathematical solution for the calorimetric differential equation which shows that the cell temperature never reaches a steady state for the F-P Dewar calorimetric cell [1,2]. However, this derivation [1] is complicated and difficult to follow if one does not have Fleischmann's mathematical abilities. A simpler method is to assume that $dT/dt = 0$ and show that the resulting equations cannot be correct under normal electrolysis conditions.

The correct differential equation for open, isoperibolic calorimetry can be expressed by

$$C_pMdT/dt = P_{EI} + P_X + P_H + P_C + P_R + P_G + P_W \qquad [1]$$

where each term is defined elsewhere [3]. If the heat transfer is only by conduction (P_C) then $P_R = 0$. For $dT/dt = 0$, Eq.1 becomes

$$(E - E_H)\, I + P_X + P_H = k_C\,(T - T_b) - P_G - P_W \qquad [2]$$

where $P_{EI} = (E - E_H)\, I$ and $P_C = -k_C\,(T - T_b)$. For the $dT/dt = 0$ conditions, the cell current (I), P_G and P_W would all be constant, and the P_X and P_H terms would be zero or constant. Furthermore, E_H is constant at a given temperature. Therefore, the derivative of all terms in Eq.2 with respect to time (t) yields

$$I\,(dE/dt) = (T - T_b)\, dk_C/dt \qquad [3]$$

This equation states that a steady state cell temperature ($dT/dt = 0$) requires that the rate of change of electrochemical power going into the calorimetric cell must be exactly equal to the rate of change of power going out of the cell by heat conduction. This is a very difficult condition for typical calorimetric cells. The tests of Eq.3 for actual calorimetric experiments yield unrealistic relationships between the experimental values for dE/dt and dk_C/dt. Therefore, the assumption of $dT/dt = 0$ is incorrect. A simple possible solution for Eq.3 is given for $dE/dt = 0$ when either $T - T_b = 0$ or $dk_C/dt = 0$. The $T - T_b = 0$ condition holds only when the cell is off and in thermal equilibrium with the water bath. For $dk_C/dt = 0$, there cannot be any change in the electrolyte level thus both C_pM and k_C would have to be constant. However, both C_pM and k_C change with time due to the electrolysis, hence there is no steady state for the cell temperature [2]. The F-P calorimetric differential equation must always be applied to experimental data for open, isoperibolic calorimeters. Many statements about errors for the F-P calorimetry are due to ignoring this important fact. This is especially true at the beginning for experiments where dT/dt is large and positive [2,3].

The testing of actual experimental data using Eq.3 will be presented. This experimental data shows that Eq.3 completely fails, thus there is no steady state for open isoperibolic calorimetry where $dT/dt=0$.

1. S Pons, Letter with 29 pages of M. Fleischmann Notes, 8 July 1992 (see LENR-CANR, Fleischmann Letters).
2. M.H. Miles, "Excerpts from Martin Fleischmann Letters", J. Condensed Matter Nucl. Sci., Vol. 19, pp. 210-218 (2016).
3. M.H. Miles, "The Fleischmann-Pons Calorimetric Methods, Equations and New Applications", J. Condensed Matter Nucl. Sci., Vol. 24, pp. 1-18 (2017).

Progress in Cluster Enabled LENR

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Initial thin-film electrolytic LENR studies lead to the investigation of ultra-high density regions of Deuterium found in voids or dislocation loops in the films [1-2] Hydrogen “clusters” in these regions were estimated to have roughly 100–1000 atoms with superconducting properties below 70 °K as shown by SQUID measurements [3]. Subsequently, ways to increase the clusters per cc were studied, typically using multiple loading-deloading techniques to build up voids and dislocation loops near film interfaces. Later, we extended these techniques to the creation of clusters in pores in nanoparticles employed in our gas loading experiments [4]. The nanoparticles are formed from various alloys ranging from Pd-rich to Ni-rich zirconia based materials. Deuterium or hydrogen gas at pressures up to 100 psi is used, with the Pd-rich or Ni-rich nanoparticles, respectively. The LENRs are initiated by an initial temperature rise associated with gas absorption in the nanoparticles. Depending upon conditions, LENR heating then rises to 300–400 °K, followed by a slow drop off over about 4 hours under constant pressure conditions. This drop off is attributed to a decrease in H/D flux with static pressure, cf. the need for voltage pulses in the earlier thin film electrolysis work. Periodic pressure variations are employed to obtain controlled runs over much longer periods. Sin addition other methods for initiation and run time control of the reactions have been investigated with varying results. The run methods have been explained in terms of flow-momentum exchange between diffusing gas ions and the clusters. Considerable attention has been devoted to studies of both Hydrogen and Deuterium pressurized nanoparticles in recent studies [5]. The relation between these studies and the earlier thin-film plus nanoparticle work will be discussed in detail.

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[5] See other presentations by IH Team members at this conference

Excess heat generation by simple treatment of reaction metal in hydrogen gas

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Reports of heat generation of reactions in the nickel-hydrogen system recently are increasing. These reaction mainly occurred with nickel together with other additive elements and hydrogen gas. We carefully cleaned the reactants and reactor and then processed in situ in the test system without exposure to air and have detected the excess heat. In these test, the thermal energy greatly exceeding the input and was continued for long time. In the best results so far, the output heat energy is twice of the input electric energy and can be lasted for several month. For example, when the input was 500 W, the excess heat can be continued for several hundred watts. It was found that the rise in temperature can be increased the output energy. We recently improved the method of preparing reactive materials and heat generation technic. This makes easier to obtain the excess heat. Here, we report the results of the new method for reactant preparation and results.

Hybrid Fusion-Fission Reactor Using Pd/D Co-deposition

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Earlier, we reported on observing the production of energetic particles during Pd/D co-deposition [1, 2]. The energetic particles produced include ≥ 1.8 MeV protons (including 15 MeV protons), ≥ 7 MeV alphas, 2.2-2.5 MeV neutrons, and secondary particles from either energetic protons and/or neutrons. We have also reported on observing the production of ≥ 9.6 MeV neutrons [3]. Such particles are energetic enough to fission uranium. Experiments were conducted in which Pd/D co-deposition was done on a composite cathode comprised of Au wire wrapped around a native uranium wire. The composite cathode was in contact with a CR-39 detector. Real-time gamma ray measurements were conducted during the course of the experiment. Changes in the baseline of the spectra and the shapes of the lines indicated that neutrons were generated, at a sufficient flux, to damage the detector. Neutron elastic scattering by Ge nuclei was modelled and the average energy of the neutrons was estimated to be 6.3-6.93 MeV. This was corroborated by the CR-39 results which showed the presence of triple tracks, Figure 1, that are diagnostic of the carbon breakup reaction, $^{12}C(n,n')3\alpha$, which has an energy threshold for the neutron of 9.6 MeV [3]. The presence of fission tracks, Figure 2, indicated that fissioning of uranium had occurred. This was verified by post-analysis using HPGe measurements in a Compton-suppressed Pb cave and liquid scintillation measurements of the spent cathode. The results of these experiments show that a hybrid fusion-fission reactor is feasible that would not produce greenhouse gases, could be easily shut-off, and could potentially be used to dispose of long-lived radioactive fission products produced by conventional nuclear power plants.

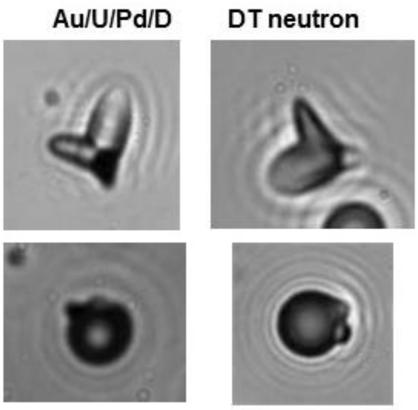

Figure 1. Examples of triple tracks observed in Pd/D co-deposition done on a Au/U cathode and their corresponding DT neutron tracks.

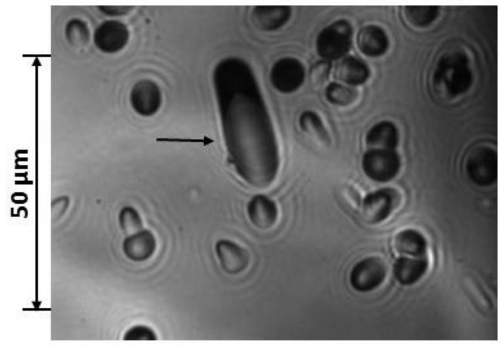

Figure 2. Fission track (arrow) observed in a CR-39 detector in contact with a Au/U/Pd/D composite cathode.

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Overview of Pd/D Co-deposition

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Pd/D co-deposition was first proposed by Stanislaw Szpak to eliminate long charging times and to create an ever-expanding electrode surface that assured the existence of non-steady state conditions and local high D loading in the lattice (D/Pd ratio ≥1). In the original protocol, working and counter electrodes were immersed in a solution of palladium chloride and lithium chloride in deuterated water. Palladium was then electrochemically reduced onto the surface of the working electrode in the presence of evolving deuterium gas. The resultant Pd deposit exhibited a uniform structure consisting of aggregates of spherical micro-globules, a large surface area, and an abundance of vacancies. Using this protocol, our group has reported that the heat source is the cathode [1, 2]. Infrared imaging of the cathode showed that heat generation occurs in the form of localized events that occur in close proximity to the contact surface. It was also observed that the higher the electrolyte temperature, the more frequent the events occurred in the cathode and that the events overlap to produce oscillating islands. We also reported on the production of tritium and energetic particles, including neutrons, as well as transmutation and the emission of γ-/X-rays [1, 2]. Furthermore, we explored the use of external electric and magnetic fields to stimulate/enhance these effects.

The Pd/D co-deposition experiment has offered great flexibility in experimental design. Different Pd plating solutions have been used by other researchers [2]. Different cell configurations (*e.g.*, parallel electrodes or concentric electrodes) have been used as well as working electrode surfaces (Au, Ag, Ni, Cu, or Pt) and geometries (wire, sheet, or screen). Closed and open system have also been used. Using variations of Pd/D co-deposition, researchers have reported on observing excess heat, gamma/X-ray emissions, transmutation, as well as the production of tritium and energetic particles.

The products observed by us and others indicate that several varieties of nuclear reactions are occurring in the system. These include primary and secondary fusion reactions to produce neutrons, protons, tritium, and ≥ 10 MeV protons and neutrons [3]. There is evidence of transmutation as shown by the production of Ag that can arise from either proton (≥ 10 MeV) or neutron capture by Pd [2]. The observation of long range alpha particles indicate the occurrence of ternary and quaternary fission of Pd [2] that is supported by the presence of such elements as Fe, Cr, Ni, and Al with a corresponding decrease in Pd [1].

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Lattice Confinement of Hydrogen in FCC Metals for Fusion Reaction

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The experimental data for the nuclear fusion cross sections at energies ≤10 keV in a number of face-centered cubic (FCC) metals manifest huge enhancements and indicate large values of the screening potential. This could imply the possibility of nuclear fusion in the metals with clusters of hydrogen isotopes with high local densities and high screening.

Our studies of the hydrogen segregation at divacancies (V_2) and impurity-vacancy (V-I) clusters in nickel using *ab-initio* calculations [1] showed a very high local concentration of hydrogen isotopes segregated to monovacancies and divacancies in FCC metals such as Ni and Pd with densities of $\approx 6 \times 10^{23}$ atom/cm^3. This is much higher than for the other known phases of H except for the core of the Sun. Calculated binding energy varies from ≈ 0.27 eV for *m*H-V clusters to 0.4 eV for *m*H-V_2 clusters and shows a sufficient stability of these clusters. The average H concentration can be further increased by doping impurities with enlarged binding energy of *m*H-V-I clusters.

These findings were confirmed by a large series of experiments on Ni samples and Ni samples with Li and Al impurities loaded with hydrogen with subsequent thermal desorption. Achieved average H concentration in Ni was $\approx 10^{21}$ atom/cm^3 , which corresponds to ≈ 1 at % of the *m*H-V and *m*H-V_2 cluster concentration.

The *m*H-V and *m*H-V_2 clusters can be viewed as the "Nuclear active environments" suggested in the review paper by E. Storm[2] and can shed light on a number of published experimental results[3].

We estimated the cross sections and reactivities for the nuclear reactions between light nuclei in Ni and Pd using the screening model based on the mean field potential of the electron cloud in the metal plasma and the experimental values of the screening potential[4]. The maximum values of the enhancement factor for the reactivity in D-D reaction was found to be for the average excitation energy E_{ex}= 2.3 eV for Ni and E_{ex}= 4.7 eV for Pd.

The ignition of the nuclear reaction requires the energies in D nuclei at least several eV, which is far above what can be achieved in the thermal heating experiments. The reaction rate for a single 6D-V cluster in Ni is estimated to be $R = 3\times 10^{13}$ s^{-1}. This high burning rate indicates that the average reaction rate in a crystal will be determined by the diffusion and segregation of H isotopes at the *m*D-V and *m*D-V_2 clusters. Thus, these clusters make the most probable environments for the LENR.

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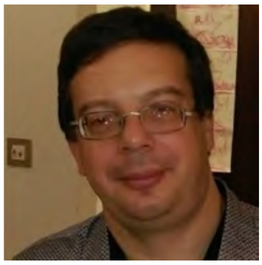
Impact of Effective Microorganisms on the Activity of ^{137}Cs in Soil from the Exclusion Zone of Chernobyl NPP



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During the development of a method for using effective microorganisms (EM) to reduce soil–plant transfer of ^{137}Cs on land contaminated with radioactive Cs, an unexpected effect of EM on the change in ^{137}Cs activity in soil samples was observed. Laboratory experiments to evaluate the impact of EM and fermented organic fertilizer (EM-bokashi) on ^{137}Cs activity in soil samples were then conducted to investigate this observation.

Sod-podzolic soil samples from the Chernobyl exclusion zone were used in the experiment. The soil samples were placed in 0.1-L containers and mixed with EM or EM-bokashi in different concentrations. Each treatment was repeated 15 times. Soil samples were kept at room temperature (20—24°C). EM is a mixture of microorganisms such as lactic acid bacteria, photosynthetic bacteria, and yeast. EM-bokashi is an anaerobic fermentation product made from solid agricultural byproducts inoculated with EM. The activity of ^{137}Cs was measured before and after an 18-month exposure to the microbiological preparations. At the time of measurement, water was added into samples to bring the solutions up to same weight as at the time of first measurement.

After the 18 months, the activity of ^{137}Cs in the samples was decreased by 0.81–4.75%. Loss of ^{137}Cs due to the radioactive decay should be about 3.39% ($T_{1/2}$ = 30.17 years). Most of the soil samples did not differ significantly from this value. However, a significant difference ($p < 0.05$) with the radioactive decay rates was observed in the samples treated with EM (1%) and EM-bokashi (1% and 5%). The differences with the radioactive decay rates slightly exceed 1% (table).

Loss of ^{137}Cs activity in soil samples in percent to the initial activity (mean ± SD)

Treatment	% of decreasing
Dry soil	0.81 ± 4.20
Wet soil	3.10 ± 1.59
Wet soil + molasses	2.91 ± 1.28
EM 1% + molasses	4.75 ± 1.62*
EM 5% + molasses	2.67 ± 2.77
EM 10% + molasses	4.50 ± 4.19
EM-bokashi 1%	4.71 ± 2.60*
EM-bokashi 5%	4.55 ± 2.19*
EM-bokashi 10%	3.08 ± 2.66
EM 10%	1.55 ± 2.24

Note: * – the differences from physical decay rate for loss of ^{137}Cs on 18 months is significant at the 5% significance level

The activity of radioactive isotopes is not affected by operations such as heating, addition of water, or addition of organic matter. It decreases only according to the law of radioactive decay. However, according to the hypothesis of bio-transmutation [1–3], some microorganisms may alter the rate of radioactive decay. The results of the experiments indicate that effective microorganisms accelerate the radioactive decay of ^{137}Cs.

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What is Rydberg Matter and Ultra-Dense Hydrogen?

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The Rydberg matter state of atoms (RM) was predicted by Manykin et. al. around 1980 and experimentally confirmed a few years later by Leif Holmlid's work. LH published a review article about RM in 2012 [1]. Here we review current state of research in Rydberg matter of Hydrogen that is showing strong signature of nuclear processes and is possibly the main mechanism behind most LENR phenomena. In the talk, various experimental and theoretical behavior of Rydberg matter of hydrogen and Ultra-dense state is discussed. An extensive collaboration effort of surface physics, catalysis, atomic physics, solid state physics, nuclear physics and quantum information is need to tackle the surprising experimental results that have so far been obtained.

Rydberg matter of Hydrogen is the only known state of matter that seems to be able to bring huge collection of protons to so short distances and for very long time that tunneling becomes a reasonable process for making low energy nuclear reactions. Nuclear quantum entanglement can also become realistic process at these conditions.

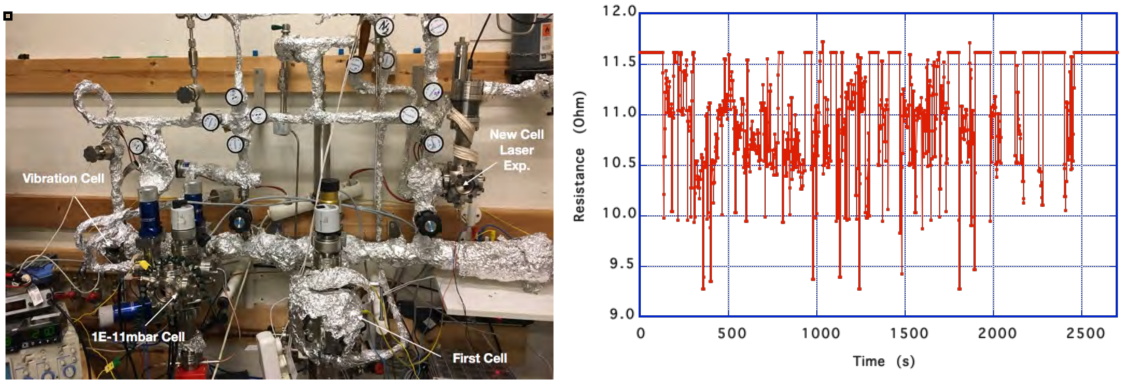

Figure. Experimental setup in Iceland and conductivity signal of Rydberg matter of Deuterium

[1] Experimental Studies and Observations of Clusters of Rydberg Matter and Its Extreme Forms Leif Holmlid. J. Clust Sci (2012) 23:5–34 Holmlid, L. & Fuelling, S. J Clust Sci (2015)

Adler–Bell–Jackiw anomaly in electroweak interactions, the $3p^+ \rightarrow 3L^+$ process and links to spontaneous UHD decay and transmutation process

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In the Oslo Norway lab, the (University of Iceland) PhD student Sindre-Zeiner Gundersen has succeeded in replicating Leif Holmlid´s work to some degree with laser type of experiments [1]. After two years of hard work and rebuilding and testing, observations with the same behaviour as Leif has published started to emerge. This is indicating how rely hard it is to get the Ultra-Dense Hydrogen phases started up in an experimental lab and replication are therefore indeed very difficult.

These results from Sindre and Leif are not typical excess heat cold fusion results found in electrochemical Palladium cells. Here high energy particles are possibly seen in the experiments.

One very recent interpretation is disintegration of the proton into lighter particles in a process of 3N-proton -> 3N-anti-lepton process. This process is allowed according to the Standard Model of High energy physics but has never been observed since it would need post big bang high temperature conditions to occur to high energy for LHC accelerator at CERN. This process could maybe solve one of the biggest remaining mystery in cosmology i.e. Baryogenisis. The hypothetical physical process that took place during the early universe that produced baryonic asymmetry, i.e. the imbalance of matter (baryons) and antimatter (antibaryons) in the observed universe.

This 3N-proton -> 3N-anti-lepton process is driven by the Adler–Bell–Jackiw anomaly in electroweak interactions in the Standard model. Why it can occur in our experiments at room temperature condition is an obvious mystery, but first idea for solution could be quantum Bose Einstein condensation of the protons or neutrons inside the Ultra-dense phase of Hydrogen. Both the spontaneous and laser induced entanglement breaking when laser pulse impinges on the condensate.

In the poster, the question how random unreliable cold fusion results in Palladium experiments and this 3N-proton -> 3N-anti-lepton process be related, will be addressed. Possible transmutation processes will also be hinted.

[1] To be published.
[2] Experimental Studies and Observations of Clusters of Rydberg Matter and Its Extreme Forms Leif Holmlid. J. Clust Sci (2012) 23:5–34 Holmlid, L. & Fuelling, S. J Clust Sci (2015)

Volcanism in Iceland, Cold fusion and Rydberg matter

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HOLUHRAUN eruption from Bardarbunga in Vatnajökull glacier in Iceland started August 2014 and ended 27 February 2015. The Holuhraun lava field measures more than 85 square km and the volume is around 1.6 km^3. It is the largest eruption for over 200 years in Iceland or since the gigantic Lakagígar eruption 1783 in Iceland. An eruption that caused famine in Europe and started in the end the French revolution. The aerosol and gas emissions from the 2014–2015 Holuhraun were extraordinary, 11Tg of SO_2[12]. The main aerosol concentration from the eruption found in Reykjavik at that time are SO_2 (25µg/m^3) in addition to H_2S, HCl aerosols [1]. Here, is presented strange correlation of conductivity measurements of Rydberg matter in the last month of the eruptions and after it, were no conductivity have been measured up to this day.

In Cold fusion and Palladium electrochemical results, there is a strange link of positive results of excess heat in countries and areas with active volcanism or high temperature geothermal area. The largest reported excess heat in cold fusion Palladium experiments was found by Melvin Miles [2] near China Lake in USA, very close to the largest geothermal power station Coso USA. Is it a coincidence that most active countries in Cold fusion research are volcanic countries such as USA, Japan and Italy? This link has not been noted strongly by the LENR research community. Are non-active palladium electrodes only found in experiments that have been far from geo-active areas?

In the article, **Thermal energy generation in the earth** by F. J. Mayer and J. R. Reitz [3] the possibility of existence of small H^- ion (called Tresino by the author) is discussed. This particle or rather the Leif Holmlid's Ultra-Dense Hydrogen phase is then possibly causing some fusion processes to occur within the earth crust with geothermal heat and Helium as product and contributing to the 43TW thermal radiation energy of the earth.

The main contribution to thermal radiation energy of the earth and hence geothermal energy is thought to be coming from decay energy chain from Thorium and Uranium isotopes in the crust. This has been estimated with some rather large uncertainty with underground geo-neutrino detector experiments or the Borexino Collaboration [4]. Allowing still cold fusion to contribute to the thermal energy budget.

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Conductivity of Rydberg matter

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Conductivity of Hydrogen Rydberg Matter Phases on Top of Pt thin film surface

The Rydberg matter state of atoms (RM) was predicted by Manykin et. al. around 1980 and experimentally confirmed a few years later by Leif Holmlid's work. LH published a review article about RM in 2012 [1]. In his later work, LH has suggested that one form of RM of Hydrogen could be a superconductor and superfluid and has experimental results supporting formation of such phase [2]. The aim of the poster is to report from current state of experiments to measure electrical properties of Hydrogen Rydberg matter and transformed phases that LH has observed and he refers to as the ultra-dense state. There are no published reports by LH or anyone found in the scientific literature were this has been studied. A custom-built experimental setup has been constructed, programmed and tested at the Science Institute, University of Iceland since 2014. Here are reported measurements with deuterium Rydberg matter that have shown very promising indications of electrical conductivity of such phases.

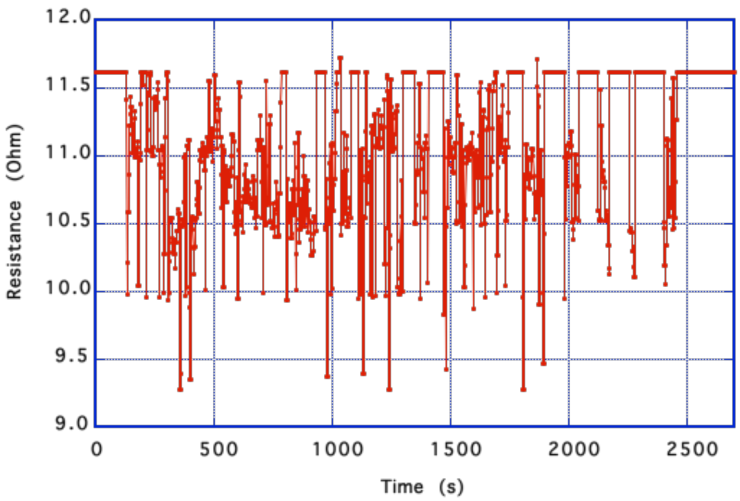

Figure 1. Resistance variations of Platinum film where 2-D Rydberg matter (D_2) layer is possibly formed on top of the Platinum film grown on top of MgO (100) single crystal surface.

[1] Experimental Studies and Observations of Clusters of Rydberg Matter and Its Extreme Forms Leif Holmlid. J. Clust Sci (2012) 23:5–34 Holmlid, L. & Fuelling, S. J Clust Sci (2015)

[2] Holmlid, L. & Fuelling, S. J Clust Sci (2015) 26: 1153

Rydberg matter experimental setup in Iceland

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The Research of Rydberg matter phases in currently active in Leif Holmlid's lab at Gothenburg University in Sweden, in Oslo S-Z. Gunderson's lab and then in Iceland. There is lot of activity in the world related to low energy reactions LENR but not within the context of Rydberg Hydrogen phases which we think could be behind most of the reported LENR strange phenomena, cold fusion, transmutation of elements and more.

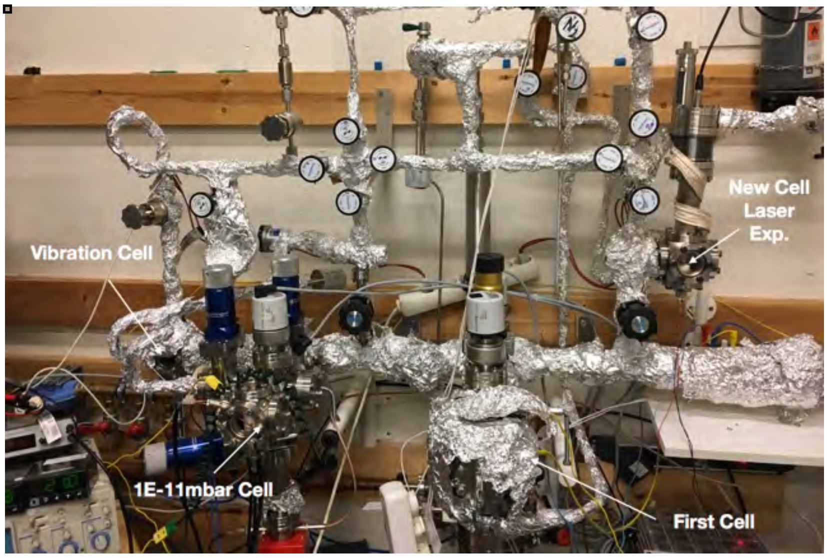

Figure 1. Experimental setup at Science Institute University of Iceland

Here we describe the Rydberg matter experimental setup that has been under construction for the last 4 years at Science Institute University of Iceland. For the last two years Technology Research Fund of Icelandic Research Council has financed an instrumentation build-up phase project that has now 4 operational cells with different functions. The first cell from 2014 has now three other cells that have specialization regarding, vibrational excitation, ultra-high vacuum pressure and laser excitation. Laser experiments are expected to become functional in middle 2018 based on experience setting up replication experiment with S-Z. Gundersen in Oslo Norway and Leif Holmlid in Gothenburg Sweden.

On highly relativistic deep electrons

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Starting from our study on the Electron Deep Orbits (EDO), we have particularly analyzed works based on the use of relativistic quantum equations, as it is to be expected that such electrons are relativistic. This hypothesis has been continuously confirmed throughout our study. Here, we quickly recall the results of a complete analysis and extension [1] [2] of the most-developed prior works [3] [4] based on the Dirac equation and the relativistic Schrödinger equation. Doing this, we discussed and countered the most common arguments found in the literature against ODEs. These arguments can be easily eliminated if we consider a nucleus of finite dimension $r_n > 0$, which removes the singularity at the origin. On another hand, as Special Relativity seems to be an essential element for obtaining EDO solutions, we showed [5] that it is actually the source of EDO's.

A second part of our work concerns the need to take into account the magnetic interactions near the nucleus. They are very energetic in the vicinity of the nucleus, but as the one-particle Dirac equation considers the Coulomb field as an external electrostatic field, it does not take into account the nuclear spin. We undertook [6] and continue the study of EM potentials that act on an electron in a deep orbit. Doing this, we are tackling two very important issues: do the EDOs satisfy the Heisenberg Uncertainty relation (HUR)? Are the orbits stable? A recent study [7], where we directly face the HUR for electrons confined in deep orbits, allows us to evaluate the coefficient γ of these highly relativistic electrons. Consequently, a high relativistic correction of the Coulomb potential yields an effective potential V_{eff} capable of confining such electrons. First approximate computations combining EM potentials, allow us to expect high-energy resonance near the nucleus. Moreover, radiative corrections could have a significant influence in this zone. Results published in the literature on the Lamb shift for heavy atoms reinforce this hypothesis. So, this paper presents some questions relating to the progress of our study:

- How to combine different attractive and repulsive EM potentials.
- From where is extracted the high kinetic energy of the deep electrons?
- The effective potential V_{eff} as a function of electron velocity and its distance to the nucleus?
- What is the order of magnitude of the radiative corrections for the EDO's?
- What is the relation between EDO solutions of the Dirac equation and high energy resonances corresponding to a semi-classical local minimum of energy?

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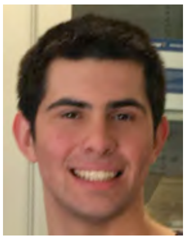
Electrical, thermal and chemical simulations of Ni-H electrochemical cells



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Measurements of LENR experiment have great value in providing information for both scientific and commercialization purposes. However, they are limited by the number of sensors that can be included in an experiment. Usually, sensors provide data at only specific points in space. By contrast, dynamic simulations of LENR experiments can proved information at all points in space and time. In our quest to understand quantitatively the behaviour of N-H electrochemical experiments, we are using a combination of measurements and simulations, as described in this paper. Two companion papers discuss the experiments [1] and analyses of data from them [2].

We are using COMSOL multi-physics finite-element software to perform simulations of the electrical, chemical and thermal behaviour of our cells [3]. The software consists of a basic multi-physics package, plus modules specific to different situations. The simulations were started by putting the geometry and materials of our cells into the software.

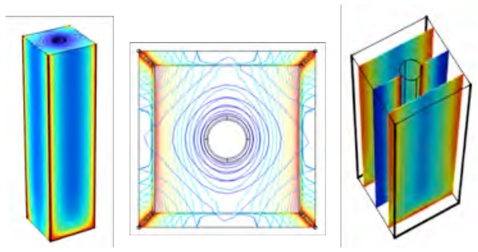

Figure 1. Left: Perspective view showing high fields in red near Pt anodes. Center: Top view showing nearly circular fields close to the Ni cathode. Right: Current density showing current convergence onto

We first used the AC/DC module to compute the electric fields, currents and heating due to the electrolyte current, followed by the Heat Transfer Module to simulate the redistribution of the resistive heat by conduction, convection and radiation. Using this approach, we computed the production and redistribution of heat due to the resistivity of the electrolyte. Figure 1 gives illustrative results. Next, we simulated the additional production of energy by LENR by using an artificial source of heat only on the surface of the submerged Ni cathode. This enabled us to compute the effects of specified amounts of excess power. Example results as a function of time after application of the voltage are shown in Figure 2.

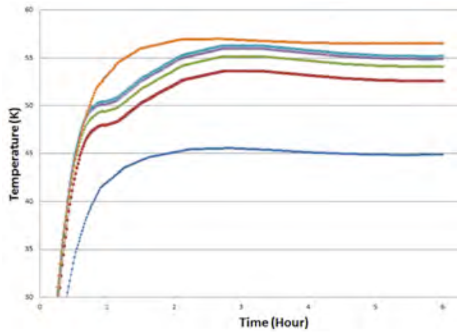

Figure 2. Simulated time histories of the central cell temperature for 6 hours. The lowest curve has no added LENR Power. The successively higher curves have 1.0, 1.2, 1.3, 1.4 and 1.5 W of simulated LENR power from the cathode surface.

The temperatures simulated by the first approach were too high compared to our measurements because the energy needed for electrolysis was not included. Hence, we used the basic program with, first the Electrochemical Module and then the Heat Transfer Module. Results using this approach will be shown in comparison to the first methodology.

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A possible signature of neutron quarks – lepton interaction in solids.

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As is well – known the strong nuclear force is responsible for holding the protons and neutrons together in the nucleus. On the other hand the nucleons are themselves made up of quarks. According quantum chromodynamics (QCD) the force holding quarks together by gluons – mediators of the strong interaction [1]. Our report is devoted to the description of the significantly new mechanism the strong force manifestation. It will be shown that an activation of the strong interaction by adding of one neutron to the nucleus causes the global reconstruction of the macroscopic characteristics of solids. We have studied the low - temperature optical spectra (reflection – Fig. 1 and luminescence – Fig. 2) of the LiH and LiD crystals which are differ by term of one neutron from each other. As demonstrated early (see, e.g. [2]) most low - energy electron excitation in LiH crystals are large - radius excitons [3]. In experiments we used the samples with clean surface cleaving in the bath of helium cryostat with normal or superfluid liquid helium. Exciton luminescence is observed when studied crystals are excited in the midst of fundamental absorption [4]. The spectrum of exciton photoluminescence of LiH (LiD) crystals cleaved in superfluid helium consists of narrow phonoless emission line and its broader phonon replicas which arise due to radiative annihilation of excitons with the production of one to five LO phonons. As an example the picture shows the low - temperature (T 2K) photoluminescence specta of LiH and LiD crystals

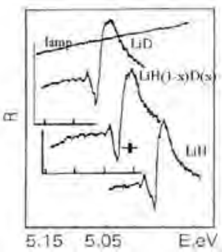

Fig. 1

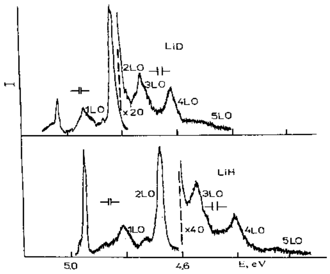

Fig. 2

Comparison the experimental results on the luminescence spectra in the crystals which differ by a one neutron only is allowed to the next conclusion.

At the adding one neutron (using LiD crystals instead LiH ones) is involved the increase exciton energy on 103 meV, (both in reflection and luminescence spectra)

As far as the gravitation, electromagnetic and weak interactions are the same of both kind crystals it only changes the strong interaction therefore a logical conclusion is made that the renormalization of the energy of electromagnetic excitations (excitons, phonons) is carried out by the strong nuclear interaction [5], which caused by quarks – lepton mechanism. The last conclusion indicates the necessity consideration the strong nuclear interaction in quantum electrodynamics (QED).

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X-ray emission in LENR by Zero Point Energy or simple QED?

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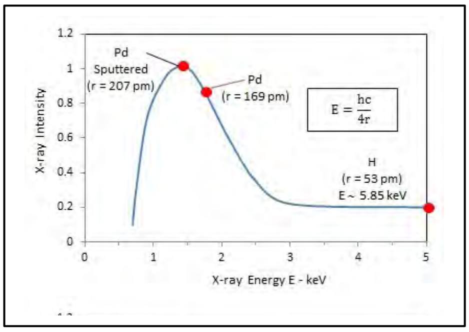
Introduction In 1900, Planck explained the radiation spectrum of a black body by treating the absorption of energy as discrete, but later assumed an average absorption energy E_{av} between (n-1) and n quantum levels, i.e., $E_{av} = ½ [nh\nu + (n-1)h\nu] = ½ [2n - 1] h\nu$. In the ground state, n = 1 and therefore E_{av} = ZPE = ½ hν. But the energy supplied to the atom may have any value between quantum levels, i.e., ZPE ≠ ½ hν, but rather ZPE < hν. Hence, the claim [1] the ZPE exists at MeV levels to explain the X-ray bursts [2] is questionable as the ZPE can only be less than the X-ray energy. In this paper, the ZPE of the atom is treated as a temporary state between quantum levels and not a quantum state of the atom. The X-ray bursts are explained by another mechanism.

Proposal The X-ray bursts in glow discharge [2] are produced by the simple QED quantum state. Simple QED is a consequence of QM that by Planck's law requires the heat capacity of the atom to vanish under high EM confinement. QM stands for quantum mechanics. Since QM denies atoms heat capacity, heat Q into the atom does not increase temperature. But atoms have high surface-to-volume ratios that requires deposition of heat Q to be almost entirely in the atom surface. Precluded from thermal expansion, the surface heat Q_s places the atom under the high EM confinement necessary in the Planck law for heat capacity to vanish. Absent heat capacity, the simple QED transition to X-ray levels occurs by converting the surface heat Q_s to non-thermal EM energy within the atom that depends solely on the atom dimensions, i.e., independent of electron energy levels. Provided the heat Q_s is deposited promptly, photons standing inside the atom are created having half-wavelength $\lambda/2 = 2r$, where r is the atomic radius. The Planck energy E of the photon standing in the atom is, $E = h\nu = hc/\lambda = hc/4r$, where c is the speed of light. If the surface heat Q_s is sufficient to reach the X-ray level, the X-ray is emitted. If not, the Q_s heat resides in a temporary state of the atom. Unable to make the X-ray transition, the Q_s heat is promptly re-emitted as EM radiation at frequency ν to combine with radiation from other atoms to make the X-ray transition. See simple QED applications: http://www.nanoqed.org/, 2010 – 2018.

Application The X-ray emission from glow discharge with Pd atoms in (Fig. 18 of [2]) is reproduced in the thumbnail. For Pd having radius r = 169 pm, simple QED gives E = 1.83 keV and wavelength λ = 0.676 nm. The X-ray peak occurs at 1.5 keV because sputtering creates Pd clusters not necessarily perfectly bare Pd atoms. Taking the classical heat flow Q from the glow discharge temperature T into the atom is, $Q = \pi r^2 HT$, where H = 5.67 W/m^2K is the convection heat transfer coefficient, and T the plasma temperature. For T = 1 eV = 11,500 K, Q = 5.85 x 10^{-15} J/s. The time τ for an individual atom to reach the X-ray level is, τ = E/Q = 50 ms, but X-ray transitions require τ < 150 fs. To induce the transition, Q > Q*, where Q* = E/150 fs = 1.95 x10^{-3} J/s. X-ray emission at heat flow Q < Q* requires a cooperative effect. For a collection of N_t atoms, a variant of the Dicke state based on the QM description of single photon absorption of heat Q from the cathode and subsequent superradiant re-emission in the same direction. In effect, the atoms cooperate by redistributing the surface heat Q_s from N_t atoms into a smaller number N having the necessary surface heat Q* to make the X-ray transition. From (Fig. 4(b) of [2]), N is the number of X-ray photons/burst ~ 1.6 x 10^8. Since N_t/N = 50 ms/150 fs ~ 3.33 x 10^{11}, a large number of N_t atoms are required to emit a single X-ray photon. When the glow discharge is turned off, the Pd atoms are still at temperature T_C of the cathode which decays slowly. Since T_C < T, the heat Q is decreased, but the X-ray emission still occurs.



Conclusion Simple QED with superradiance explains X-rays in LENR without the ZPE or nuclear reactions.

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Observation of Excess Heat in Nickel – LAH System

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The replication of Parkhomov's approach [1-4] of getting excess energy with Nickel and Lithium Aluminium Hydride system is being attempted since two years at Swami Vivekananda Yoga Anusandhana Samsthana (S-VYASA deemed-to-be University) in the Centre for Energy Research lab, which has been exclusively created for understanding LENR phenomena. After nearly 50 experiments and after having satisfied that, the experimental setup, Instrumentation and measurement systems are well established, couple of experiments showed indication of sudden rise in the core temperature; when all the other parameters continued to be remain same.

The picture of the setup and the measured parameters of one of the experiments is presented in this paper.

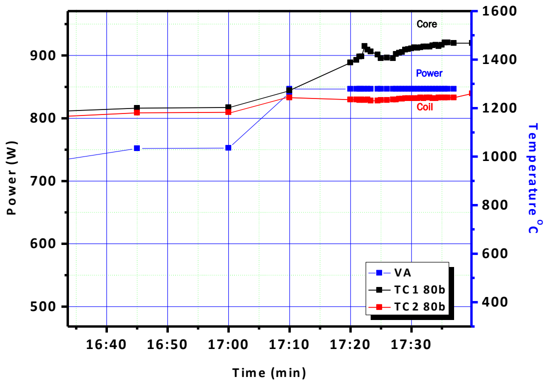

Fig1: Plot of Power (W) & Temperature (^{O}C) Vs Time (min) for one of experiments showing sudden rise in the core temperature

Fig2: Picture showing the reactor in operation along with the power and Temperature display

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A Method to Initiate an LENR Reaction in an Aqueous Solution

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This paper reports a protocol that enables one to initiate an apparent LENR reaction in a specific solution and under specific conditions. The protocol consists of a series of steps taken in a sealed reactor, involving heating an aqueous solution of a soluble polyhedral silsesquioxane that hosts lithium ions in a cubic cage to within 5°C of the solution's boiling point, then applying electrical and photonic stimuli between conductive electrodes immersed in that solution over an extended period. After that stimulation, the temperature of the solution is raised above the boiling point. The pressure is then reduced in an impulse, thereby driving a phase change in the solution. That phase change has been demonstrated to initiate an exothermic reaction, followed by a momentary reduction in both temperature and pressure, as would be expected when pressure drops in such a reactor and the gas expands. However, within a very short time after the pressure drop, the temperature rises in both the solution and the headspace above it. That temperature rise violates Gay-Lusasc's Law and is evidence the reaction is exothermic.

Chemical Heat Generation in LENR

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Over the past nearly 30 year history of LENR there have been a number of reports of explosions in experiments and other thermal events that many attribute to an LENR effect. However, before advocating LENR it is necessary to make sure that no prosaic chemical or physical reactions can explain, at least partly, the results observed.
This paper addresses 2 types of phenomena where chemical effects may have contributed to the events.

1- Abnormally strong detonations
During electrolysis of water a mixture of hydrogen and oxygen is produced that can accumulate in the headspace of the cell. Under some conditions, an explosion that is uncommonly strong can arise. Examples are the explosion event presented in 2014 by Jean-Paul Biberian at ICCF-17 in Korea or the explosion that occurred in 1992 at the laboratories of SRI International at Menlo Park, California. The strength of the detonation was such that it seemed logical to envisage the role of LENR to explain the powerful explosions. Further investigations made by the authors show that a particular phenomenon called SWACER (Shock WAve Coherent Energy Release) can play a role. The effect has been reproduced. Examples are shown. Some safety advices to avoid such catastrophic explosions in the future are presented.

2- Self-heating of hydrogen loaded palladium cathodes exposed to the air
The potential chemical effects that arise in charging a palladium metal lattice with deuterium to such a degree that a latent chemical potential resides in the metal could theoretically contribute to vigorous heating effects. In particular, when a deuterium-loaded sample is exposed to air, combustion can occur. The chemical reaction increases the temperature. This accelerates the escape of the gas out of the metal, enhancing further the combustion process. If some b phase was present its dissociation contributes to the heating. A model of the temperature evolution during such a process is presented. The role of the different parameters is explored. It is shown that high temperatures can be reached.

The object of the paper is not to necessarily show what occurred in various events that have been observed over the years, but simply to open the possibilities of a contribution from chemical effects arising under the circumstances.

Complex current fluctuations in Ni-H electrochemical experiments: Characterization using non-linear signal analysis

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The sophistication of the analysis of data from low-energy nuclear reactions (LENR) experiments has varied widely. While Fleischmann and his colleagues, for example, did diverse and thorough analyses of data from the calibration and performance of their calorimeters [1], overall, there has been relatively little analysis of the temporal histories of the temperatures or electrical currents within LENR electrochemical cells. Here, we report on detailed analyses of the current fluctuations within electrochemical cells with Ni cathodes and light water electrolytes. These analyses are part a three-prong research program aimed at understanding Ni-H electrochemical approaches to the production and control of LENR. Two papers describe the experiments [2] and their simulations [3].

We analysed time-series from electrochemical LENR experiments with electrolytes of K_2CO_3 or Na_2CO_3, and electrode potentials of 3 to 5 V. In particular, we determined (i) how the fluctuation magnitude and the fractal dimension (D_F) of the time series depend on the electrode potential, and (ii) if the complexity of the signals can be captured by analysing the multiscale time irreversibility (MTI) [4]. The analyses revealed that (i) the fluctuation magnitude depends non-linearly on the electrode potential (power-law), (ii) that D_F increases with electrode potential, (iii) the MTI is able to quantify the scale-dependent complexity of the electrochemical signals (see Fig. 1), and (iv) that characteristics of large fluctuations in the data follow lognormal distributions. The MTI generally increases with the electrode potential applied in the cell. As shown in Figure 1, the signals show sawtooth-shaped fluctuations on multiple scales, with a sudden increase and a slower decay. The complexity and the sawtooth pattern indicate the presence of one or more dynamic mechanisms at the electrode-electrolyte interface. Departures of gas bubbles from the cathode surface probably contribute to the observed behaviour, giving a background against which we hope to detect the effects of LENR.

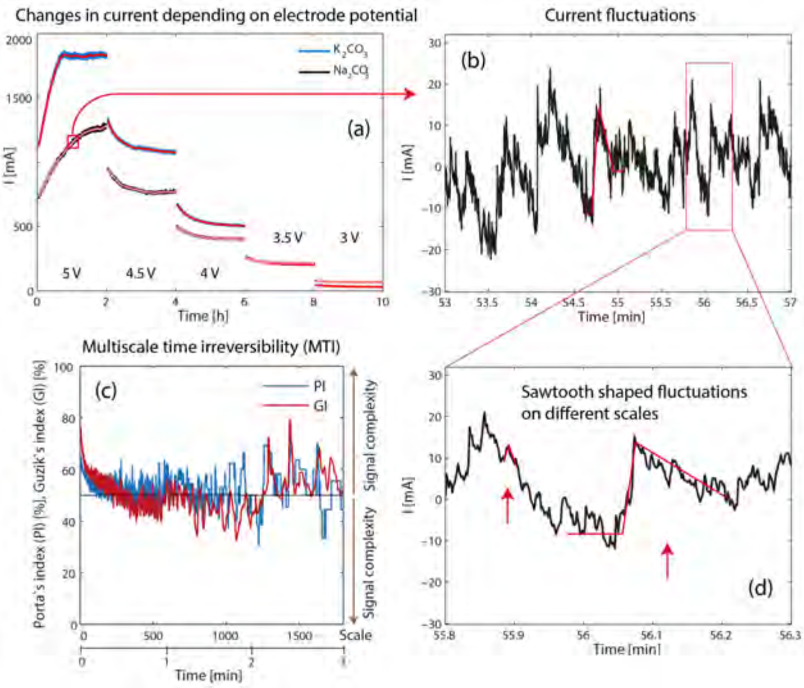

Figure 1 Visualization of one data set: raw data (a), enlarged sections of the current fluctuations (b, d), and the result of the multiscale time irreversibility analysis (c). A deviation from the horizontal line in (c) from 50 % indicates complexity of the time-series, i.e. asymmetric shapes of the fluctuations.

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Experience with Semiconductor Technology Development Potentially Relevant to LENR

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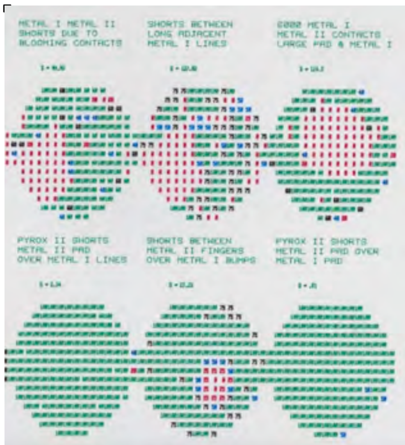
The author had the experience of developing an advanced integrated circuit technology, and a computer system based on the technology. Some of the lessons learned there might be applicable in accelerating commercial realization of LENR, despite significant technology differences.

Between 1978 and 1982, a team of 15 Hewlett Packard process development engineers and 30 VLSI design engineers worked in Ft. Collins CO. They developed and put into production a 1 micron, double-level tungsten-metal integrated circuit technology that was 50 times denser and five times faster than competitors In parallel, the group developed a computer system based on that technology [1]. The system included six chip designs with up to 600K transistors per chip. The technology won best paper awards two years in a row at the International Solid State Circuit Conference, the premier conference on solid-state circuits and systems [2].

The project was much more than just a research effort, being also the basis for 2000 people’s livelihood. In addition, it produced a rapid methodology in solving the many, mostly unplanned and somewhat subtle problems. A useful set of tools and paradigms emerged which greatly accelerated problem resolution. Some of these tools were not initially obvious to the R&D focussed team.



Six of approximately 150 vital parameters shown. Failing regions shown in red. Goal: 150 maps all green, achieved.

Fifteen lessons learned for yield improvement included these:

- Small teams can deliver dramatic results, if they *stay* focussed.
- Cycle time through experiments is directly related to convergence rate on solutions to problems.
- Unit process control, and both cradle-to-grave and chemical tracking are essential.
- Easy-to-use, comprehensive, automatic diagnostic tools and special test structures greatly simplify otherwise difficult problems.
- Intermediate gains are important to maintain team morale and funding for continuing development.

Yield in semiconductor production is conceptually equivalent to success (reproducibility) in LENR experiments. We believe that some of the lessons learned in semiconductor technology development may be germane to research and commercialization of LENR. If funding of LENR development were adequate, it would be possible to use the iterative, focused practices from the massive semiconductor industry to speed knowledge, commercialization and exploitation of LENR.

Materials are central to LENR, as they are in the semiconductor industry. Systematic parameter variation experiments with diverse materials, using robust experimental setups with multiple monitors and serious data analysis, would require team efforts and significant funding. But, they have the potential to bring LENR to market sooner and with greater confidence, compared to the current diverse, and usually-disconnected and widely-distributed, experimental efforts in the field.

[1] *www.hpl.hp.com/hpjournal/pdfs/IssuePDFs/1983-08.pdf*.

[2] Jim Mikkelson, Lawrence Hall, Arun Malhotra, S Dana Seccombe and Martin Wilson, ”An NMOS Process for fabrication of a 32b CPU chip”, IEEE International Solid State Circuit Conference, New York City, Vol. 24, pp.106-107, 1981

Coupled Calorimetry and Resistivity Measurements, in Conjunction with an Emended and More Complete Phase Diagram of the Palladium - Isotopic Hydrogen System

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Results of a calorimetric study established the energy produced, over and above the input energy, from electrolytic loading of deuterium into Pd was 150 MJ/cc of Pd (14000 eV/Pd atom) for a 46 day period. High fugacity of deuterium was developed in unalloyed palladium via electrolysis (0.5 molar electrolytic solution of lithium deteroxide, LiOD) and the use of an independent electromigration current. In situ resistivity measurements of the Pd were used to assay the activity of D in the Pd lattice (ratio of D/Pd) and employed as an indicator of phase changes. In addition, during this period, two run-away events were triggered by suddenly increasing the current density resulting in 100 percent excess power (2.4 watts output with only 1.2 watts input) necessitating a temporary cut back in the electrolysis current. The average excess power (excluding run-away) ranged from 4.7 +/- 0.15 to 9.6 +/- 0.30 percent of input power while the input power ranged from 2.000 to 3.450 watts, confirming the Fleischmann-Pons effect. The precision was: Power In = +/-.0005 W; ΔT = +/- .05^{o}C; Power Out = +/-.015 W giving an overall precision of +/- 0.5%. High fugacity was required to produce these results, and the triggered run-away events required even higher fugacity. Using thermodynamic energy balance, it was found that the energy release was of such magnitude that the source of the energy is from a nuclear source, however the exact reaction was not determined in this work. X-ray diffraction results from the recent literature, rules for phase diagram construction, and thermodynamic stability requirements necessitate revisions of the phase diagram, with the addition of three *thermodynamically stable* phases of the superabundant vacancy (SAV) type. These stable phases, each requiring high fugacity, are: γ ($Pd_7VacD_{6\text{-}8}$), δ phase (Pd_3VacD_4 - octahedral), δ' phase (Pd_3VacD_4 - tetrahedral). The emended Palladium – Isotopic Hydrogen phase diagram is presented here. The excess heat condition supports portions of the cathode being in the ordered δ phase (Pd_3VacD_4 - octahedral), while the drop in resistance of the Pd cathode during increasing temperature and excess heat production strongly indicates portions of the cathode also transformed to the ordered δ' phase (Pd_3VacD_4 - tetrahedral). These phases were encouraged by the used of an electromigration current causing the D+ ions (trapped to vacancies) to pull the vacancies along and aid the formation of the SAV phases. The heat increases with increasing volume fraction of the new phase. Extending these basic unit cells to the larger lattice epiphanates the nuclear active state as the δ and δ' phases. The decreased resistance phase, δ', is modeled in the same way by extending the unit cell to the entire lattice revealing extensive pathways of low resistance. A potential connection of these phases to the superconductivity phase of PdH / PdD is offered.

Isotope Effects beyond the Electromagnetic Force: ^{1}H and ^{2}H in Palladium Exhibiting LENR

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A mechanism is presented concerning electrolysis of deuteriated water with a palladium cathode that is infused with deuterium (palladium deuteride) resulting in the formation of small amounts of radioactive tritium, excess energy (more than allowed by EMF chemistry alone) and the concomitant liberation of ^{4}He. This net electron catalyzed nuclear chemical reactions ($^{2}H + {}^{2}H + e^{-} \rightarrow {}^{4}He + e^{-}$ + heat) and ($^{2}H + {}^{1}H + e^{-} \rightarrow {}^{3}H + e^{-}$) appear to be a result of respectively four and three isotope effects [1] acting in combination with each other in a non-linear (chaotic) fashion to produce a metastable nuclear isomer of hydrogen-4 or hydrogen-3. The four isotope effects begin with the influx of electrons into the –Pd-D-Pd-D- Bravais lattice conduction band and consequent preferred rupture of Pd-D bonds (over those of Pd-H) in the cathode liberating D_2. This is followed by the newly freed deuterium capturing an electron yielding a di-neutron (${}_{o}n_{o}n$). The ${}_{o}n_{o}n$ then reacts with a deuterium or hydrogen (from protic impurity in the lattice) via phonon enforced quantum tunneling resulting in ^{4m}H or ^{3}H respectively. The ^{4m}H quickly undergoes nuclear internal conversion to form ^{4}He. These reactions involve the weak force, but they take place in simple electrochemical systems that are normally thought of in terms of the electromagnetic forces only.[2] The combined influence of the four isotope effects explains thousands of, what were considered, anomalous observations by top electrochemical researchers.[3] The newly described mechanistic effects involve a very important and almost forgotten intermediate (the di-neutron).[4]

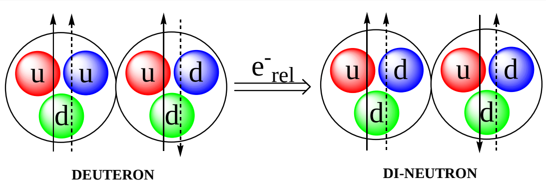

Figure 1: A simplistic representation of the two "spin" quantum numbers identifying the nucleons before and after capture of a relativistic electron. On the left, the deuteron is a spin triplet (both solid arrows up) and an isospin singlet (one dotted arrow up and the other down). Electron capture is symmetry breaking, and on the right the di-neutron is depicted as a spin singlet and an isospin triplet. Both ${}_{o}n_{1}p$ and ${}_{o}n_{o}n$ are anti-symmetric with respect to exchange. This is essential as ${}_{o}n$ and ${}_{1}p$ are identical with respect to the strong nuclear force.

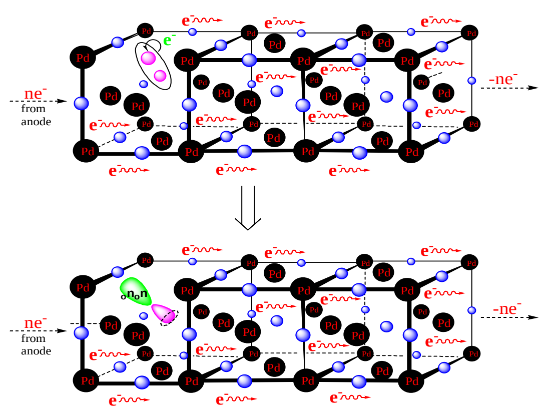

Figure 2: (Upper) A representation of the electron Capture of a deuterium in D_2 (upper), caged in a PdD lattice afforded by the vacancy. (Lower) This yields a di-neutron (left ovoid) and deuterium (right ovoid) with a single electron in close proximity.

[1] C. D. Stevenson, Annulenylenes, annulynes, and annulenes, *Acc. of Chem. Res.* 40, 8, 703–711, **2007**.
[2] A M. Fleischmann, S. Pons, M. W. Anderson, L. J. Li, M. Hawkins, Calorimetry of the palladium-deuterium-heavy water system, *J. Electranal. Chem. Interfacial Chem*. 287, 2, 293–348, **1990**.
[3] M. McKubre, F. Tanzella, P. Tripodi, Evidence of d-d fusion products in experiments conducted with palladium at near ambient temperatures, *Trans. Am. Nucl. Soc* 83, 367, **2000.**
[4] H.-W. Hammer, S. Konig, Constraints on a possible dineutron state from pionless EFT, *Phys. Lett. B* 736, 208–213, **2014**.

The enthalpy of formation of PdH as a function of H/Pd atom ratio and treatment

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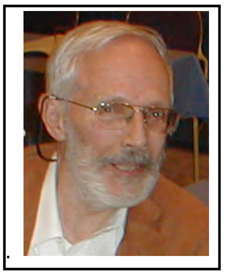

Production of the LENR effect involves achieving a large concentration of D in the PdD lattice structure. A great deal of effort has been applied to understanding how this can be accomplished and the nature of the resulting structure. The bulk properties play a role in this process but are sensitive to the impurity content and treatment. The influence of the bulk properties on this process has not been fully explored.

This paper describes a new method to directly measure the bond energy between the PdH structure and the contained H atoms in real time as a function of H/Pd ratio from zero to the maximum H content using the electrolytic method and H_2SO_4+H_2O to react Pd with H. A unique and very accurate calorimeter (±5 mW) is used to measure power during the loading reaction. This method is applied to several types of Pd including commercial Pd sheet, extra pure Pd, and a zone refine single-crystal of Pd after each is subjected to several treatments. These treatments include repeated loading-deloading cycles, annealing at 900°C, and reduction in thickness. The bond energy is found to be sensitive to purity, treatment, and H/Pd ratio, with good agreement with published measurements being achieved after certain treatments. In addition, three methods to measure the average H/Pd ratio are described and compared. These methods use weight gain, orphaned oxygen, and recombiner temperature. A great deal of information about the reaction process can be obtained by combining these three methods because they are sensitive to different possible errors and behaviours.

Figure 1 compares the initial loading process and Fig. 2 compares the enthalpy of formation for the three different samples before the effect of treatment is explored. The bond between H and the lattice becomes repulsive (endothermic) as the upper H/Pd limit is approached.

The study has revealed unexpected behaviour and a new method to explore the environment in which LENR occurs.

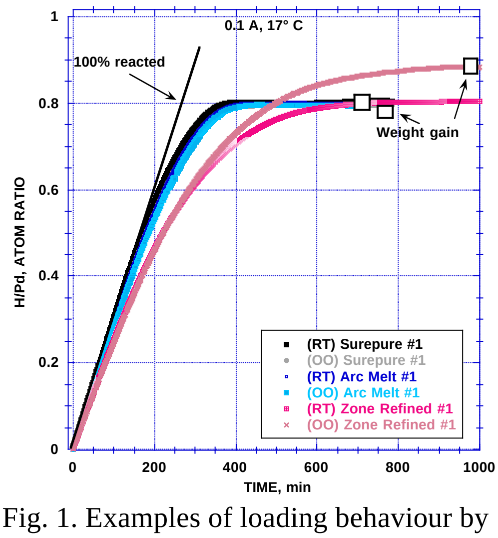

Fig. 1. Examples of loading behaviour by comparing the three different measurements of H/Pd ratio, where RT is recombiner temperature and OO is orphaned oxygen.

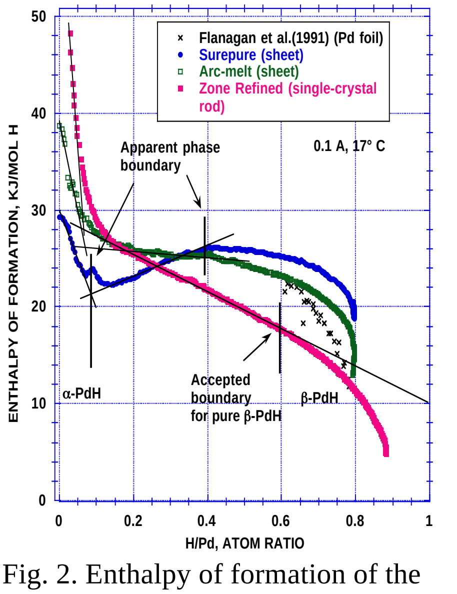

Fig. 2. Enthalpy of formation of the three types of Pd before treatment. Values are measured every minute.

The Loading and Deloading Behavior of Palladium Hydride

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The ability to initiate LENR is believed related to being able to create PdD with a large D/Pd ratio. Various treatments have been applied to the surface to achieve this goal, with focus on loss reactions involving surface reactions being the primary cause limiting the deuterium content. This paper explores the effect of another loss mechanism involving surface penetrating cracks and flaws. These features allow hydrogen gas to leak out as bubbles (Fig. 1) at a rate related to a diffusion process that is not affected by applied current. This diffusion rate can be quantified by measuring the loss and relating it to the square root of time, an example of which is shown in Fig. 2. This relationship applies when loss occurs in the electrolyte after electrolytic current is stopped, in acetone, or in air. Extrapolation to zero time allows the final D/Pd ratio to be determined after current is stopped and the slope allows the contribution of this loss process to be determined while current is applied. Samples that load to a D/Pd ratio less than about 0.75 appear to show a loss rate by this process that is nearly equal to the rate at which D is applied by the current. Therefore, samples able to achieve a larger D/Pd ratio appear to have a loss rate determined by two mechanisms, loss from cracks and loss by surface reactions, i.e. the Tafel effect. Therefore, both mechanisms must be controlled to achieve a large D/Pd ratio.

FIGURE 1. Bubbles of H_2 from Pd in acetone

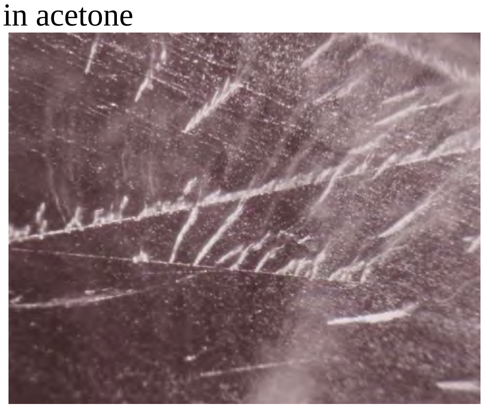
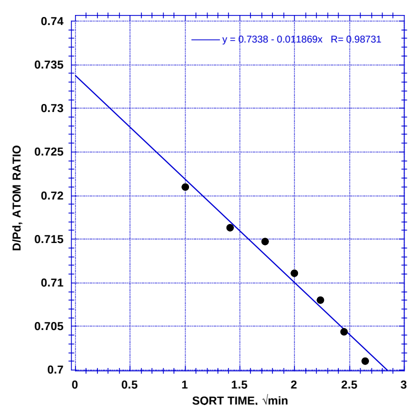


FIGURE 2. D/Pd vs square root time in air



The process of loading and deloading produces an unusual response by the shape and volume of the PdH structure. Repeating this process many times causes a plate of Pd to eventually assume the shape of a cube. In the process, the physical volume increases. Some samples are more susceptible to this process than others. Experience has shown that samples that do not readily change shape this way are more likely to host LENR.

The strange behavior of catalysts made from Pd or Pt applied to Al_2O_3

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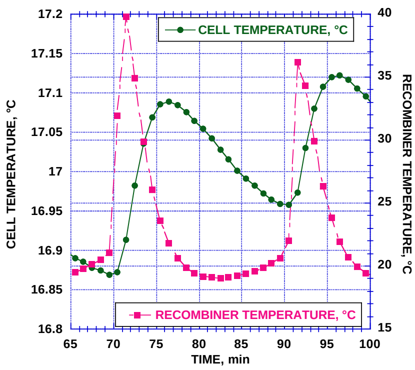
Studies of LENR using electrolysis frequently employ a catalyst in the cell in order to turn excess D_2 and O_2 gases back to D_2O liquid. Accurate measurement of power requires the efficiency of the catalyst to be high and very reliable. The commercial catalysts based on $Pd+Al_2O_3$ and $Pt+Al_2O_3$ frequently used for this purpose have been found to exhibit poor reliability and novel behavior.

In particular, the catalyst has been observed to show a regular periodic turning on and off that occurs for significant duration at unexpected times. This behavior can give false information about excess energy production. Figure 1 shows an expanded example of a few cycles showing how the change in recombiner temperature changes the cell temperature. Once started, this periodic process can last for long times, as shown in Fig. 2. As this figure shows, the reaction at the recombiner can change the apparent excess energy and the open circuit voltage (OCV).

FIGURE 1. A few cycles showing effect of recombiner temperature on the electrolyte temperature



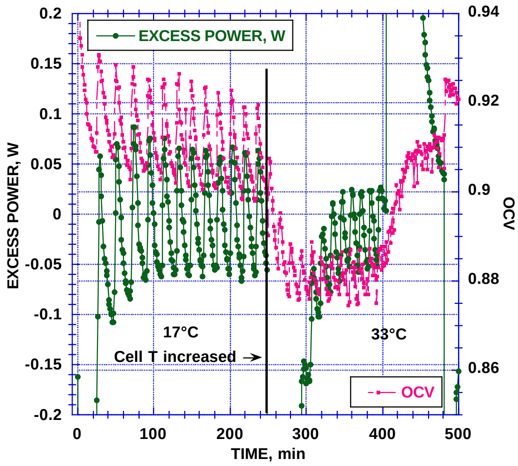


FIGURE 2. Example of many cycles and their effect on excess power and open circuit voltage.

This behavior allowed an unexpected feature of the recombination process to be revealed. The response of the calorimeter and OCV were much faster than could be caused by normal conduction of heat energy. Apparently, radiation, was produced that could pass through 3 mm of Pyrex and change the temperature of the surrounding thermoelectric converters. At the same time, the chemical activity of D in the surface of the cathode is increased after the radiation has passed through the electrolyte. Use of either normal hydrogen or deuterium in the electrolyte produced the same effect.

Investigation of Cavitation Effects Related to LENR

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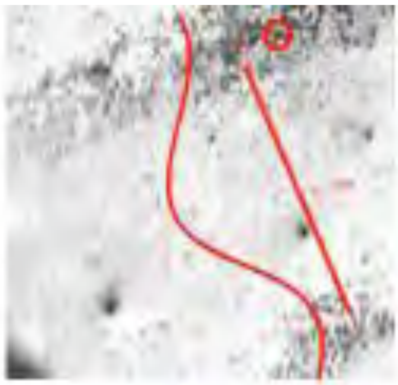
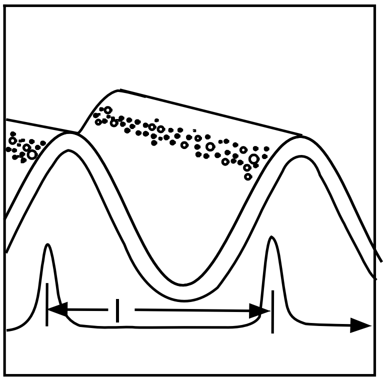
Several high frequency cavitation experiments have produced interesting data. A new miniaturized cavitation system was operated at 1.7 MHz using D_2O and was small enough to fit into a sensitive Seebeck calorimeter. The 1.7 MHz reactor was designed to pass 50 ml of D_2O in 120s through the 1cc cavitation volume. This procedure minimized heating of the transducer and target foil, however after each run, the D_2O had to be cooled prior to another test. Strategically placed thermocouples (TCs) at the entrance and at the exit from the cavitation cell measured the delta T to supplement the Seebeck data. Many different target foils (TF), (5 x 18 x 0.1mm) were run in the system and a few showed some interesting surface features. Tritium barely above the background was found in one sample, and while sample to sample variations occurred in the heat output, none was greater than 10%. The melted PdAg alloy TF SEM is shown below.

SEM of TF Pd/Ag



Target foil (Pd/Ag6%)

Cavitation activity



$l = 5.9\text{x } 10^{-7}$ m

SEM of the PdAg TF exposed to D_2O cavitation for 120 seconds. The wave pattern is shown in the exaggerated drawing. This shows the active zone at about 10% as measured in earlier measurements. [1]

[1] R. Stringham, Sonofusion's, "Transient Condensate Clusters", JCMNS, Jean-Paul Biberian Ed., Vol. 13, 508, 2014.

A Deuteron Plasma Driven to Neutrality and ^4He

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Old recovered data of 20 KHz cavitation experiments, where free electrons and deuterons that implanted into metal target foils, TF, of Pd and Ti, were measured for ^4He atoms. The activity occurs in sub-picosecond timeframes at ~10^oK that effectively limit activity to the surrounding mobile electrons in the D^+ Meso Clusters, MC. The systems that were measured in cavitating D_2O, ranged in frequencies from 20 to 1600 KHz. The positive ^4He mass spectrometry, MS, results can be explained by postulating a squeezed existence of implanted charged particles in the MCs. These focusing and compressing free electrons squeeze and neutralized the MC plasma. This environment was close to that of the Recombination Epoch, which is "The universe after 380 thousand years of cooling". Electrons could finally unite with protons forming H. In our experiment, e- + D^+ was the 1driving force. The probability of D atom formation becomes greater than zero as MC cools, producing the ignition shockwave, SW. The production of one atom of ^4He was related to D ionization potential of 15.5 eV. The MC generates in its space-time a high-density fast pulse SW that ignites an MC DD fusion event much like the space-time of muon molecule Ddμ fusion, where a comparison can be made. [1] The energy density pulse of the MC shockwave pulse was much greater than the molecular muon fusion pulse Ddμ. See table. These numbers are estimates but express the magnitudes for the comparison of D+ + e- SW with the slower pulse of the Ddμ molecule.

SINGLE EVENT POWER PLUSE COMPARISON   P = dE/dt = F*v

VALUES	MC SHOCKWAVE		Ddμ MUON
Energy in Joules	2.48E-18		3.81E-12
Active radius in meters	8.00E-15		8.00E-13
Volume of fusion activity	2.33E-42		2.33E-36
E/V Ratios J/m3	1.06E+24		1.06E+24
Pulse capture time sec	5.00E-14		1.00E-08
Power pulse J/(m3*t)	2.13E+37		1.06E+32

This paper explores the paths of TFs BCC and FCC unit crystals that followed different ^4He paths regarding trapped ^4He in Ti and ejected ^4He in Pd. 1) Ti TF lattice, BCC, showed no SEM photo evidence of small surface ejected craters, but an MS of the melted foil pieces showed by MS were trapped ^4He in the Ti TF. [2] 2) Pd TF FCC lattice, showed many small surface ejecta craters, ejected MS, in SEM photos, but the MS of melted pieces of Pd TF lattices showed no significant trapped ^4He.

[1] Kanetada Nagamine, Introductory Muon Science, 1st-ed edition, Cambridge University Press, New York, pp.80-87, 2003.
[2] R. Stringham, Helium Measurements from Target Foils, LANL and PNNL, 1994, JCMNS, vol. 24, Proceedings ICCF20 Sendai, Japan, Oct 02-07, 2017.

Aqueous and Nanostructured CF/LANR Systems Each Have Two Electrically Driven Modes

Mitchell Swartz, JET Energy, Inc.

Successful lattice assisted nuclear reactions [CF/LANR] use highly-loaded hydrogen binary alloys to create "excess heat" [XSH] and other products [1]. The original method (aqueous, low impedance Pd/D_2O/Pt) had low efficiency and poor reproducibility which created havoc for the inexperienced in metallurgy, electrochemistry, contamination avoidance, and protocols such as optimal operating point operation. This paper reports that calorimetry, H_2 gas measurement, and CMORE spectroscopy [Coherent Multiwavelength Optical Reflection Electric-driven] have revealed two distinct states ["modes"] of electrical-driven performance. Importantly, only one is the active, desired, excess heat[XSH]-producing mode [2]. Figure 1 reveals the two different electrically-driven states beyond "off": "on-" (not active, no excess heat), and "on+" (active, with XSH) for aqueous and dry systems. Note that the two methods confirm each other for both aqueous and dry preloaded LANR systems, and corroborate the existence of two electrically driven states – one inactive and the other active [XSH-producing]. As a corollary, both aqueous and nanostructured LANR systems, when active, have distinct calorimetric and CMORE antiStokes-XSH linked signatures. Knowledge and use of them has considerable value when seeking active systems, and understanding some past difficulties.

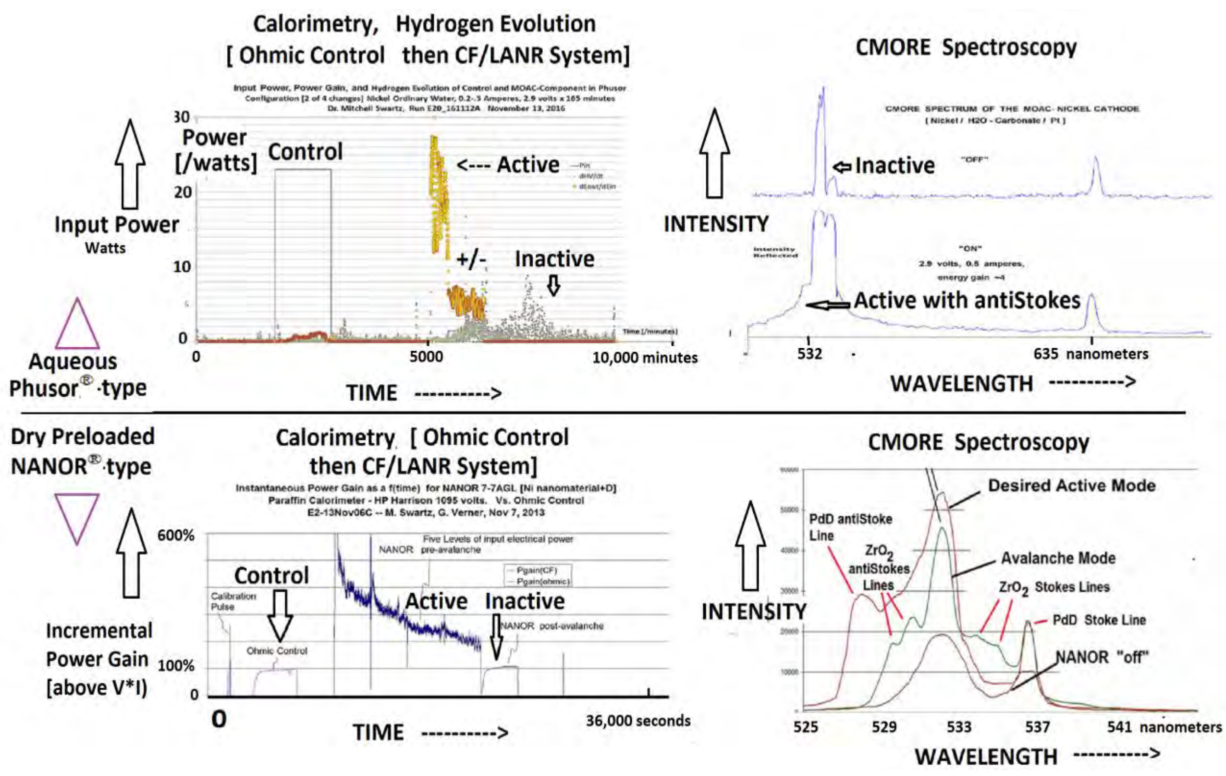

Figure 1 – Two Electric-Drive Modes Revealed for LANR Systems

Calorimetry (including incremental power gain, & the rate of XSH- and H_2 production) are on the left; CMORE spectra are on the right. The top row is from an aqueous Ni ordinary water system (Pt anode, PHUSOR®-type); the bottom row is from a dry ZrO_2-NiPdD NANOR®-type component.

[1] Swartz M.R., *Excess Power Gain using High Impedance and Codepositional LANR Devices Monitored by Calorimetry, Heat Flow, and Paired Stirling Engines*, Proc. ICCF-14, 1, (2008), 123; ISBN: 978-0-578-06694-3, 123, (2010); www.iscmns.org/iccf14/ProcICCF14a.pdf

[2] Swartz, M.R. *Optical Detection of Phonon Gain Distinguishes an Active Cold Fusion/LANR Component*, J. Condensed Matter Nucl. Sci., 20, 29-53 (2016).

Excess Heat is Linked to Deuterium Loss in an Aqueous Nickel CF/LANR System

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[1]JET Energy, Inc. [2] Lincoln Laboratory, MIT

We report some of the results from MIT's Lincoln Lab from 1993 to 1996, and supplementary recent data from JET Energy, Inc. These results indicate a loss of deuterium from ordinary water when excess heat is observed in an aqueous Ni system using a very large cathodic area. The MIT Lincoln Laboratory Electrolytic Cell system had a 3 liter capacity [cathode 4.7 pounds made from #46 hard drawn smooth nickel wire (0.041 mm diameter, area ~240,000 cm^2), anode platinized sheets of titanium (~3,200 cm^2), 0.6 M K_2CO_3 in laboratory distilled deionized "ordinary" water, and two internal ohmic controls (Figure 1)]. In addition to energy measurements, gas measurements and isotopic measurements were obtained. The early MIT experiments had input electrical powers ~25 watts. The maximum power gains were 5 to 14 times electrical input when the thermoneutral correction was used. When using V*I as electrical input power, the maximum incremental power gain was ~4 times electrical input; this occurred at lower electrical input power. The maximum excess power was ca. 5 watts. The exit gas from the enclosed electrolytic cell, using ~100% collection by liquid nitrogen condensation in the recombiner, generated ranged from 2 to 100 cc/minute [2.8 to 144 liters/day]. Isotopic analysis was made by mass spectrometer (INFICON Quadrapole-102 Volt Energy)[2]. The HD/H_2 isotopic ratio [3/2 ratio] was less for gas leaving the cell, with some recovery in the recombiner water. Figure 2 shows the HD/H_2 isotopic ratios at different locations at the end of a long run. This result heralds deuterons as the fuel. It is consistent with Swartz *et alia* [ICCF9, 3] and probably with the reports of helium production in Pd systems [4]. Importantly, deuterons and their isotopic flow [5], including in ordinary water systems, must be considered as the fuel for active aqueous nickel CF/LANR systems.

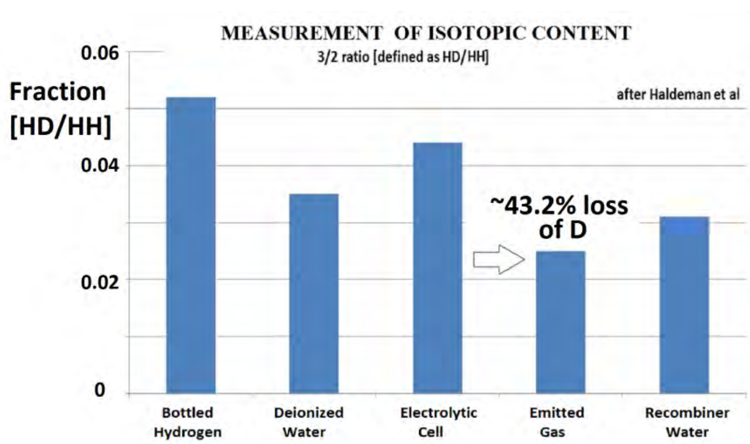

Figure 1 (left) -The electrolytic MOAC ["Mother of all Cathodes"] cell, unfilled; before refilling and adding supplemental diagnostics. **Figure 2** (right) - 3/2 [HD/H_2] Ratios at various system locations.

[1] Swartz M. R., *Excess Power Gain using High Impedance and Codepositional LANR Devices Monitored by Calorimetry, Heat Flow, and Paired Stirling Engines, Proc. ICCF14* 1, (2008), 123; ISBN: 978-0-578-06694-3, 123, (2010); www.iscmns.org/iccf14/ProcICCF14a.pdf
[2] Haldeman, C.W. E.D.Savoye, G.W.Iseler, H.H.Clark, "*Excess Energy Cell Final Report*" (1996).
[3] Swartz. M., G. M. Verner, A. H. Frank, "*The Impact of Heavy Water (D_2O) on Nickel-Light Water Cold Fusion Systems*", Proc. ICCF9, China, Xing Z. Li, pages 335-342. May (2002).
[4] Miles, M. et alia, *"Correlation of excess power and helium production during D_2O and H_2O electrolysis using palladium cathodes", J. Electroanal. Chem.*,1993, 346, 99-117.
[5] Swartz, M., "*Quasi-One-Dimensional Model of Electrochemical Loading of Isotopic Fuel into a Metal"*, *Fusion Technology*, 22, 2, 296-300 (1992).

Using Laser Ablation of Metals to Evaluate a Proposed Formation of Ultra Dense Deuterium

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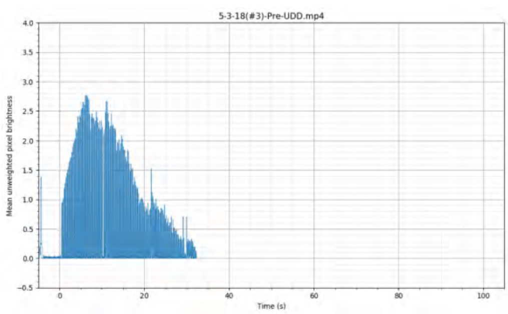
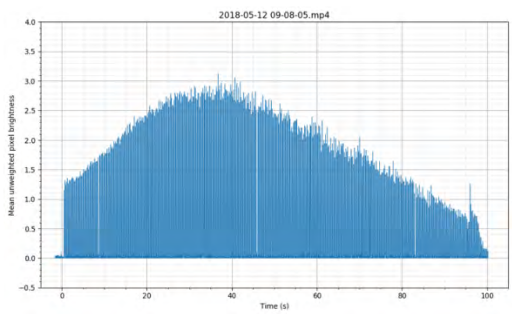
Dr. Leif Holmid is a professor Emeritus in atmospheric chemistry at the University of Gothenburg in Sweden. His area of research is primarily Rydberg Matter (RM). The material discussed here is Ultra Dense Deuterium (UDD), a type of RM according to Holmlid. He has published more than 40 papers over 15 years on RM and Ultra Dense Protium and Deuterium. His work involves several types of laser based spectroscopy including TOF, rotational spin and others.

I have worked in 3 labs over the past five years, working towards finding an analysis tool that can show that a dense formation of deuterium occurs when the right conditions are met.

Early on, because particle characterization from laser triggering is very tricky, I decided to see if I could measure changes in surface conductivity, as Holmlid believes UDD is highly conductive. I worked for 4 months on this at the University of Idaho. My setup was quite good but the results were inconclusive. In early 2017 I got lab space at Southern Utah University and I was able to borrow a Nd-YAG pulsed laser from a chemist at the University of Utah. I built up a vacuum system with a UHV chamber and parts from various suppliers. After introducing the deuterium gas flow the system pressure is in the 5-10 mTorr range using a 2 stage Edwards mechanical pump. I use a Continuum Laser at 10 Hz, 532 nm and generally at 80 mJoule/pulse. I have a 200 mm focusing lens and a spot size on the target of approx 75 micron. The lens is mounted to a linear micro-adjust platform for precise settings.

My experimental approach is to get videos and oscilloscope readings of the plume intensity (via charge detector) and burn through rate of each laser run. I am able to see exactly when the laser exits the back side of the material. 1 mm thick Stainless Steel was the primary metal but I also use Copper, Titanium and others. A typical experiment is that I start gas flow and take baseline measurements. I then move the target perpendicular to the laser with a single axis manipulator to a fresh spot adjacent to the control. Flow rates of gas are in the 1-5 sccm range. Readings are taken over the next several days. The KFeO2 catalyst (for industrial process dehydrogenation) is heated (typical 60C) by a DC power supply and heater block. Over 60 metal targets have been studied and the results are quite clear. When the catalyst is working properly, the ablation time increases from 200% - 350%. Something over 500 laser runs have been made over 12 months.





Typical duration and plume intensity from control to several days. 30 seconds to 95 seconds to burn through (mean pixel brightness from video capture).

Research Status of Nano-Metal Hydrogen Energy

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Two MHE facilities at Kobe University and Tohoku University and a DSC (differential scanning calorimetry) apparatus at Kyushu University have been used for excess-heat generation tests with various multi-metal nano-composite samples under H(or D)-gas charging. Members from 6 participating institutions have joined in planned 16 times test experiments in two years (2016-2017). We have accumulated data for heat generation and related physical quantities at room-temperature and elevated- temperature conditions, in collaboration. Cross-checking-style data analyses were made in each party and compared results for consistency. Used nano-metal composite samples were PS（Pd-SiO_2）-type ones and CNS(Cu-Ni-SiO_2)-type ones, fabricated by wet-methods, as well as PNZ（Pd-Ni-Zr）-type ones and CNZ（Cu-Ni-Zr）-type ones, fabricated by melt-spinning and oxidation method. Observed heat data for room temperature were of chemical level.

Results for elevated-temperature condition: Significant level excess-heat evolution data were obtained for PNZ-type, CNZ-type CNS-type samples at 200-400℃ of RC (reaction chamber) temperature, while no excess heat power data were obtained for single nano-metal samples as PS-type and NZ-type. By using binary-nano-metal/ceramics-supported samples as melt-span PNZ-type and CNZ-type and wet-fabricated CNS-type, we observed excess heat data of maximum 26,000MJ per mol-H(D)-transferred or 85 MJ per mol-D of total absorption in sample, which cleared much over the aimed target value of 2MJ per mol-H(D) required by NEDO. Excess heat generation with various Pd/Ni ratio PNZ-type samples has been also confirmed by DSC (differential scanning calorimetry) experiments, at Kyushu University, using very small 0.04-0.1g samples at 200 to 500℃ condition to find optimum conditions for Pd/Ni ratio and temperature. We also observed that the excess power generation was sustainable with power level of 10-24 W for more than one month period, using PNZ6 (Pd_1Ni_{10}/ZrO_2) sample of 120g at around 300℃. Detail of DSC results will be reported separately. Summary results of material analyses by XRD, TEM, STEM/EDS, ERDA, etc. are to be reported elsewhere.

Plasmonic Field Enhancement on Planar Metal Surfaces

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The power density supplied to deuterium-metal systems is a key to initiate the nuclear reaction. We previously proposed and analyzed the electromagnetic energy focusing effect around metal nanoparticles and nanoshells to significantly increase the reaction probability [1,2]. In the present work, we show that such a plasmonic field enhancement occurs also on planar metal surfaces. Removing the noble-metal approximation in Ref. 3, we have fully calculated the maximum field enhancement for the metals commonly used in the community (Fig. 1). The main formula to represent the field enhancement factor, defined by the ratio of the spatial electromagnetic energy densities with and without the metal object, is summarized as:

$$\eta \equiv \frac{\left|\vec{E}_{SP}\left(0^{+}\right)\right|^{2}}{\left|\vec{E}_{0}\right|^{2}} == \frac{c\left(\left|q_{1}\right|^{2}+\left|k_{SP}\right|^{2}\right)\cos\theta\left(1-R\right)}{\omega\varepsilon_{1}^{1/2}k_{SP}''\mathrm{Re}\left\{\frac{k_{SP}\left(\varepsilon_{1}q_{1}'+\varepsilon_{2}q_{2}'\right)}{\varepsilon_{2}q_{1}'q_{2}'}\right\}}$$

, where we followed a set of common notations in electrodynamics and the subscripts *1* and *2* denote the surrounding medium and the metal, respectively. Notably, our calculation is only based on the Maxwell equations and involves nothing exotic or physically novel. We have thus found that a certain degree of enhancement is available on the metal-surface regions, implicating that this electromagnetic boosting effect had been unconsciously exerted in the experiments reported so far, particularly for the electrolysis-type ones. Importantly, this plasmonic enhancement occurs for the case of an optical-power incidence as well as an electric-bias application. It is therefore important to design and optimize the experimental systems, including the materials choice, structures, and operation conditions, additionally accounting for the plasmonic energy enhancement effect around the gas (vacuum)/liquid-metal interfaces. This sort of numerical model, incidentally, is simple and flexible to connect to other ones, and may construct a comprehensive model by combining with transport and reaction submodels [4], for instance. Further details of our present work are found in Ref. 5.

a) **b)**

Fig. 1 Field enhancement factors on planar Pd, Ni, and Ti surfaces in (a) D_2/vacuum and (b) D_2O.

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Nanosecond Pulse Stimulation in the Ni-H_2 System

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Brillouin Energy and SRI International (SRI) have been performing calorimetry measurements on the Ni/ceramic/Cu coatings in a H_2 atmosphere with nanosecond pulses applied between the Ni and Cu. The reactive cores have been described earlier [1]. We have been testing new materials, material fabrication techniques, and electrical stimulation methods to produce power and energy output in excess of that reported earlier. In addition to the pure metals, we have investigated systems using Ni-Pd coatings.

By applying fast pulses [2] of several hundred volts and tens of nanoseconds long, the current follows the "skin-effect" principle and is concentrated at the Ni-ceramic interface but returns through the bulk of the Cu. Two stimulation methods were used – steady-state and dynamic. In the steady-state method, the pulse power is measured directly using fast oscilloscopes that record the voltage across the core and a shunt resistor in series with the core. The input pulse power is determined by multiplying the calculated root-mean-square voltage and current and recorded every 10 seconds. Figure 1 shows typical waveforms collected from the oscilloscope and the calculated pulse power.

Using a sophisticated model of the calorimeter with up to 15 coefficients, the power reaching the five temperature sensors is determined during simultaneous continuous ramps of both heater and pulse powers. The power emanating from the core is determined during sequences of more frequent low voltage pulses (LVP) and compared to that found using less frequent high voltage pulses (HVP). The power determined during the more frequent LVP is set as the input power during that sequence. The power of the stimulation pulses during the less frequent HVP sequences is maintained equal to that during the more frequent LVP. Then the power calculated from the core is divided by that calculated during the reference sequences, giving a so-called coefficient of performance (COP). Table 1 below presents some of the recent results obtained using this dynamic stimulation method. Because the analytical method used for the dynamic stimulation is different from that used earlier with steady-state stimulation, a correction was applied for better comparison. The corrected results are presented in the last column in the table. The actual excess powers in the first column are up to three times greater than those measured earlier.

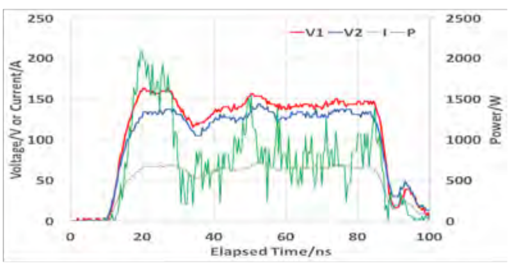

Figure 1. Stimulation pulse power analysis

QREACTION /Watts	COP using DS method	COP using legacy method
3.62	1.25	1.56
3.59	1.26	1.55
3.90	1.27	1.62
4.91	1.31	1.56
4.99	1.31	1.58
4.85	1.31	1.58

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The Mechanism of Formation of LENR in Earth's Crust

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The importance of electricity in the development of Earth’s geology is not readily apparent, it is not a rarity, but fundamental to many processes. Structural breakdowns deep in the Earth's mantle require exceptional conditions, combining the powerful electrification of rocks and the formation of ‘weakened zones’, partially melted high-conductivity zones which occur in the subduction lithosphere.

The latest seismic and seismological data has made it possible to reveal the rotary mechanism which drives geospheres from the Earth’s core towards the surface. The speed of this rotation increases with depth but is made possible only in the presence of a plasma core, of a type similar to ball lightning which has existed since the formation of our planet. The rotary motion of ball lightning (also called plasmoids) has been studied in modern times since it may be the basis of cold nuclear fusion (LENR). Rotation of sub-surface geospheres generates electricity and is responsible for the dynamo effect of planet Earth. Energy produced in this way accumulates in the lithosphere, which has the properties of an electric capacitor.

The plates of this natural condenser are rock strata, and the dielectric medium between them is the fluid that circulates between these layers, which causes a radiative effect and the cooling of nuclear processes. From the standpoint of plate tectonics, these fluids are formed in subduction zones. During absorption in these regions, rocks are ground into powder by the "millstone effect", cause by the different speed of movement of the plates (seams) and geospheres. Deep fluids dissolve and transport soluble rocks (clay, limestone, etc.) over long distances, forming basal packets along which the migration of fluids is favoured. Within these basal packets and karsts electric field strength increases until it exceeds the dielectric strength of the medium, at which point breakdown occurs and these charges are neutralised. Inside the discharge channel plasma is formed in which numerous physical and chemical processes occur. This phenomenon of charge build-up followed by discharges can also occur in the interior of dielectric rocks and voids. Spark discharges in the earth's interior, when a lot of energy is released in a spark channel, can trigger earthquakes.

Proof that such processes occur is provided by the spherical nodules found in all ore and coal mines. Study of these nodules will make it possible to create the correct conditions for the formation of spherical plasma formations with a large kinetic energy. Mine explosions give us some idea of the potential power of this process. During the penetration of productive strata, there are cavities or karsts, which may sometimes contain ball lightning, which miners call "shubins" or"bunnies". It is these highly energetic electric phenomena in the earth's crust that also form Kimberlite explosion tubes.

A different subterranean chemical environment is associated with the presence of plasmas of cold nuclear fusion, in which the transmutation of elements occurs. In these reservoirs there may be a discharge in the form of a spark or current pulse, or just a weak direct current caused by variations in salt concentration in the formation electrolytes. This LENR process is possible because of the presence of plasmas of various forms, which possess both gravitational and magnetic fields and are able to process the surrounding material into geological bodies of different types. It is possible that such processes lead to the formation of various deposits of polymetals, coal, rocks and minerals. We have also conducted the first verification experiments to simulate reservoir conditions: Inside a simple reactor chamber a pressured environment was created in the presence of a magnetic field and electric discharges. Unfortunately, no elemental analysis has been performed, but very promising results were obtained - after the initial excitation of electrical discharges, a voltage appeared on the stator**,** which suggests the formation of a condenser-like structure inside the reactor.

Using the Method of Coherent Correlated States for Realization of Nuclear Interaction of Slow Particles with Crystals and Molecules

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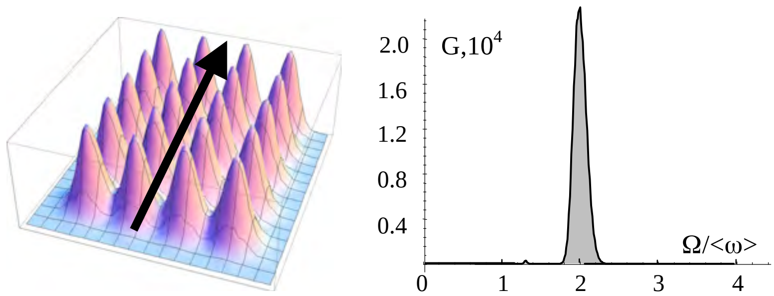
In the report the possibility and peculiarities of effective nuclear fusion based on the interaction of low energy proton beams with the nuclei of the crystal surface or gas of free molecules are discussed. In [1-4] a general and universal mechanism for LENR optimization based on the application of coherent correlated states (CCS) of interacting particles was considered. This mechanism provides a high probability of LENR and can be applied with the same efficiency to different experiments. It should be noted that the CCS method makes it possible to explain different LENR paradoxes on the basis of standard quantum mechanics and modern nuclear physics without involving fantastic heuristic models. The physical basis of this method is related to the Schrödinger-Robertson uncertainty relation $\delta p \delta x \geq \hbar / 2\sqrt{1-r^2} \equiv G\hbar/2$, where $|r|\leq 1$ is a *correlation coefficient* and $G = 1/\sqrt{1-r^2}$ is the *coefficient of correlation efficiency*. In the works [1-3] it was shown that the mechanism of the formation of CCS with sharp increase of G up to $G \geq 10^3 \div 10^4$ can be realized when the particle is localized in the field of a nonstationary harmonic oscillator. In particular, the maximum rate of G increase corresponds to the case when the oscillator modulation frequency Ω is twice the average frequency ω of the oscillator. In this case if the particle is localized in a potential well with a width $\delta x = L$, then the kinetic energy fluctuations $\delta T^{(\min)} = (\delta p)^2 / 2m = G^2\hbar^2 / 8mL^2$ are very large.

This mechanism can be successfully implemented when, for example, a proton moves in the periodic field of crystal with the period d (Fig., left). In the rest system of the proton such motion corresponds to a nonstationary harmonic oscillator with the frequency $\Omega = vd$. In this case (e.g. in Li crystal with $<\omega> \approx 6 \cdot 10^{14} s^{-1}$) the optimal condition for CCS formation corresponds to the optimal proton velocity $v_{opt} = 2<\omega>/d \approx (3\div 4).10^7 cm/s$ and optimal longitudinal energy $E_{opt} = mv_{opt}^2/2 \approx 500 eV$ of the moving proton.



It was shown that at such condition the correlation efficiency of moving proton reaches a very large value $G \geq 25000$ (see Fig., right) to the end of 3rd÷4th periods of the crystal lattice, which leads to the generation of giant fluctuations $\delta T^{(\min)} \geq 30 keV$ of transverse energy of the particle and realization of $Li^7 + p = 2He^4$ reaction. Nearly the same effect, but with some differences, takes place when a slow proton moves through the inhomogeneous (nonstationary in a rest system) field inside a single Li_2 molecule.
All these results are in good agreement with very interesting experimental data [5].

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Effective LENR in Weakly Ionized Gas Under the Action of Optimal Pulsed Magnetic Fields and Lightning (Theory and Experiments)

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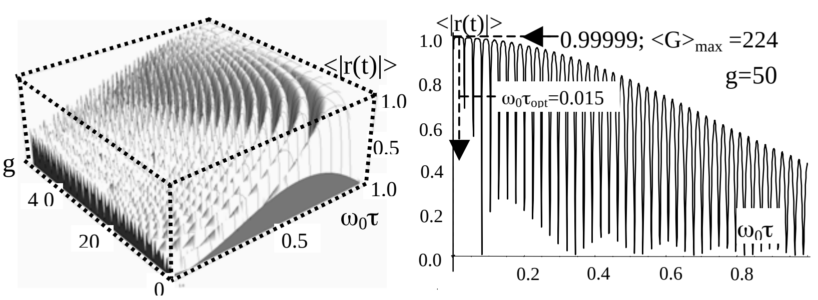
Numerous successful LENR experiments, some of which have confidently emerged from the "child" age of laboratory experiments and have manifested themselves at the industrial level, up to now are not based on a reliable theoretical model that adequately explains non-trivial results that are not consistent with the traditional models of nuclear physics. In [1], a general and universal mechanism for LENR optimization based on coherent correlated states (CCS) of interacting particles was considered. In this regime the particle state is characterized by very large synchronized fluctuations of momentum and kinetic energy that can reach many tens of keV. The physical basis of this method is related to the Schrödinger-Robertson uncertainty relations $\delta p \delta x \geq \hbar / 2\sqrt{1-r^2} \equiv G\hbar/2$, $\delta E \delta t \geq G\hbar/2$, where |r|≤1 is a *correlation coefficient* and $G = 1/\sqrt{1-r^2}$ is the *coefficient of correlation efficiency*. In a correlated state, the value G can reach very large values $G \geq 10^3 ... 10^4$ and it leads to a very significant increase of the tunneling probability

$$D_{r\neq 0} \approx \exp\left\{-\frac{2\sqrt{1-r^2}}{\hbar}\int_R^{R+L(E)}\sqrt{2M\{V(q)-E\}}dq\right\} = \left(D_{r=0}\right)^{\sqrt{1-r^2}} \quad \sqrt[G]{D_{r=0}}$$

at any low energy. Usually these effects are considered in condensed systems with controlled interaction between guest particles and matrix nuclei that is similar to nonstationary oscillator.

Another alternative method of CCS formation is connected with a pulsed change of the frequency of an equivalent harmonic oscillator under the action of a pulsed magnetic field on free charged particles [1]. A typical example of such external action is an electric discharge in a gas or liquid. The current J(t) of the discharge is accompanied by the formation of a pulsed azimuthal magnetic field in which the motion of the ions corresponds to tunable cyclotron resonance, and the system itself is a complete (formal) analog of the nonstationary harmonic oscillator with the same Hamilton operator, wave functions and energy spectrum. Used in [1,2] formalism for the formation of a CCS in such oscillator can be fully applied to magnetic system, taking into account the obvious change of the frequency $\omega(t) = |q| H(t)/Mc = \omega_0\{1 + g e^{-(t-t_0)^2/\tau^2}\}$. It was shown that the optimal condition for CCS formation at such pulse action is the following: $g\omega_0\tau \equiv \tau |q| H_{max}/Mc \approx 0.6 \quad 0.7$. On Fig. (left) the 3D plot of the time-averaged correlation coefficient <|r(t)|> versus the duration τ and amplitude g of the symmetric Gaussian pulse magnetic field acting on the particle and (right) the same coefficient <|r(t)|> for the case g=50 is presented. The maximal value of correlation coefficients at such condition is $|r|_{max} \approx 0.9999997$ and $G_{max} \approx 1290$. It was shown also that at pulse duration τ=0.1÷1 μs the optimal magnetic field pulses with $H_{max} \approx 0.6 \div 6$ kOe are required. For such parameters $D_{G\approx 1290} \approx 1$. These results explain the realization of LENR both in laboratory experiments with pulse discharge and in processes stimulated by lightning very well [2].



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Generation and Registration of Undamped Temperature Waves at Large Distance in LENR Related Experiments

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In the report the results of generation, detection and study of fundamentally new physical phenomena (*undamped high frequency temperature waves*, which can exist in different environments only at certain frequencies) are presented and discussed. These phenomena were found during experiments on the study of LENR processes at water jet cavitation [1-4].

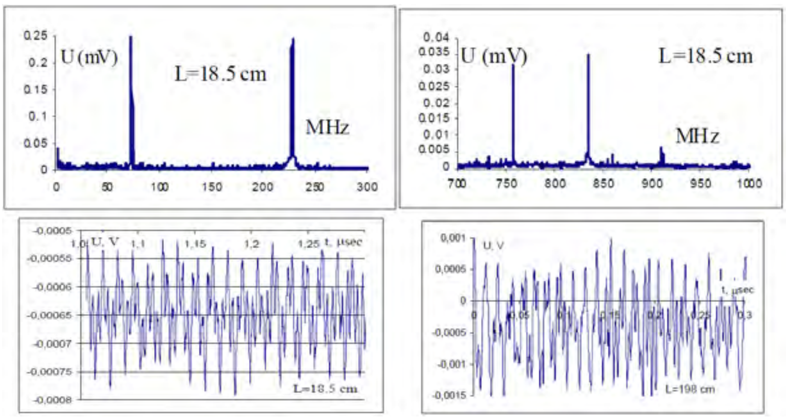
A few years before these observations we carried out a detailed study of the features of thermodynamics in real environments [1,2]. In these studies it was shown that the equations of thermodynamics, in particular, the equation of thermal diffusivity $\partial T(r,t)/\partial t = G\,div\{grad[T(r,t)]\}$, contain approximations that are incorrect in media with a long thermal relaxation time τ. The solution of this "traditional" equation is a superposition of plane waves

$$T(\omega,x,t) = A_\omega e^{-\delta x} e^{i(\omega t-\kappa x)} + B_\omega e^{\delta x} e^{i(\omega t+\kappa x)},\ \kappa=\sqrt{\omega/2G},\ \delta=\sqrt{\omega/2G}$$

where G is a thermal diffusivity coefficient. This solution shows that temperature waves produced on the basis of uncorrect equation are characterized by a very strong damping with a factor $\delta=\sqrt{\omega/2G}$, which is equal to the wave number κ. The solution of modified equation of thermal diffusivity $\partial T(r,t+\tau)/\partial t = G\,div\{grad[T(r,t)]\}$ [1-4] is

$$T(\omega,x,t) = A_\omega e^{-\delta^* x} e^{i(\omega t-\kappa^* x)} + B_\omega e^{\delta^* x} e^{i(\omega t+\kappa^* x)},\ \kappa^*=\kappa\cos\omega\tau/\sqrt{1+\sin\omega\tau},\ \delta^*=\kappa\sqrt{1+\sin\omega\tau}$$

For the waves with frequencies $\omega_n=(n+1/2)\pi/\tau$, which correspond to condition $\cos\omega_n\tau=0$, the damping coefficient δ is equal to zero, and the general solution of this equation has the form of a superposition of the direct and inverse undamped temperature waves. In the air, under normal conditions, the minimal frequency of such wave corresponds to 70÷90 MHz and in metals and semiconductors it is 1÷100 THz. In our experiments these waves are generated via cavitation processes and registered in the air at a large distance that is limited only by the experimental conditions. The spectrum of these waves and their structure at different frequencies and different distances from the cavitation zone (at L=18.5 cm and L=198 cm) are shown in figures. In LENR processes in metal matrix such waves with $\omega\approx 10\div 100\,THz$ can be excited at local fast processes similar to $Li^7+p=2He^4$ reaction.



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Controlled transmutation of Na, P and Mn to Fe isotopes in D_2O and H_2O during growth of yeast Saccharomyces cerevisiae

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Over the last 10-15 years we have optimized the method for the realization of nuclear reactions for transmutation of stable and radioactive isotopes in growing *syntrophic microbiological associations* [1-4]. The most significant achievement was the creation and optimization of technique for transmutation of radioactive Cs^{137} nuclei into a stable Ba^{138}, which makes it possible to reduce the number of active nuclei by two times in two weeks (acceleration by 500-1000 times as compared with the natural spontaneous decay). On the other hand, we would like to reanimate (revive on the base of a new level of understanding both the processes and mechanisms) our previous investigation of efficient isotope transmutation in pure microbiological cultures (such as *Escherichia coli*, *yeast* and others) which we have conducted about 20 years ago [5-7]. According to our "old" date the total efficiency of transmutation for such cultures was 20…30 times less than in *syntrophic associations* [1-4]. Our new investigations will allow a more detailed study of both the process of isotope transmutation and understand of some abnormal processes in food and medical technologies.

Lately we have conducted several series of such experiments using food yeast. In these experiments we again observed a significant change in the concentration of different elements and isotopes. For example, in a medium based on light water H_2O and in the presence of salts of certain chemical elements (Na, N, C, Ca, P, Mn) we recorded a decrease in total mass of manganese ($\Delta M_{Mn} \approx -1.47$ μg) and a simultaneous increase in the mass of iron ($\Delta M_{Fe} \approx 1.31$ μg) in small volume bottles (50 ml). These effects are connected with LENR reaction $Mn^{55}+p=Fe^{56}$.

In a similar light water medium (but without of Mn salt) we have observed significant change in the isotopic composition (isotopic ratio) of impurity iron - instead of the standard (natural) ratios of isotopes ($Fe^{54}/Fe^{56}/Fe^{57}$=5.85%/91.75%/2.11%), we have registered other ratios ($Fe^{54}/Fe^{56}/Fe^{57}\approx$10.0%/87.7%/2.1%). These changes are the direct results of creation of Fe^{54} isotope in $Na^{23}+P^{31}=Fe^{54}$ reaction that takes place at deficit of iron in nutrient media.

We also have received and investigated a lot of another transmutation reactions in these test experiments - e.g. creation of Fe^{57} in reaction $Mn^{55}+d=Fe^{57}$ of transmutation in heavy water media.

Full results will be presented after the completion of the research cycle which we conduct together with scientists from Sweden and Norway.

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Electrochemical Immittance and Transfer-function Spectroscopy applied to LENR

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CR-39 solid state nuclear track detectors have detected the emission of high energy particles from active LENR electrodes and liquid scintillation detectors have detected the generation of tritium. Linear Energy Transfer (LET) curves in water for ionizing radiation indicate that such radiation will propagate considerably further than the double layer thickness produced during electrolysis. This suggests that the electrical characteristics of an active LENR electrode during codeposition, loading and operation will exhibit different properties when observed in real time via Electrochemical Immittance Spectroscopy (EIS). These changes could be an indication of the active electrode properties such as effective porous surface area, diffusion/mass transport level and LENR activity.

We have developed an EIS capability which is incorporated into our real time multichannel instrumentation system that allows continuous observation, data reduction, and recording of EIS data. Both frequency-domain and time-domain digital electrochemical immittance and transfer-function spectroscopy will be discussed. Explicit as well as implicit frequency diversity systems will be examined considering, implementation and performance as well as cost. The presentation will include a discussion of the EIS system design and implementation as well as a summary of our findings.

Joseph Papp Nobel Gas Engine Shows Early LENR?

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The poster will cover the history, experiments and technical insights of the inventor Joseph Papp and his noble gas engine and connect them to the LENR paradigm. There are three separate demonstrations and explosions (~10^{12} J/Kg) that occurred with this noble gas technology: one with the Naval Undersea Warfare Laboratory and the other in the Environetics parking lot (1968) and at TRW in the presence of many witnesses including Dr. Richard Feynman. A technical forensic content analysis of the patents and lawsuits will be presented. A timeline of the technology development from the beginning in Hungary to Papp's death in 1989 will be shown. Many sources are used in this preparation, from FBI interviews, newspaper articles, police files, court documents, corner reports, magazine articles and TRW witness interviews. Legal counsel responsible for managing the court-ordered settlement for Papp and Environetics was interviewed. A summary of technical claims and sources will be presented and analyzed.

The results of the technical data investigation show that a reasonable man would conclude that there is novel energy. This is likely accomplished by some LENR process not fully understood. One theory of operation is that a gaseous photochlorination chain reaction in the presence of hydrogen (via electrolysis) and spark ignition in a toroidal cylinder causes a rapid expansion and then slower recombination of gases inside the Papp Engine. Walter Nernst (Nobel Prize in Chemistry) worked in this area and R.G.W. Norrish's science in photochemistry showed that chlorine & hydrogen have sharp limits of pressure, varying markedly with temperature, below which the chain reaction is slow and above which it becomes explosive. This may be what is happening in the Papp Engine. This conclusion is based on the, historical science, witness testimony, film evidence, patents, official interviews and one historical certified power-in power-out controlled test. However, to date this technology although allegedly replicated by several independent groups has failed to create a working engine system for high quality 3rd party validation testing.

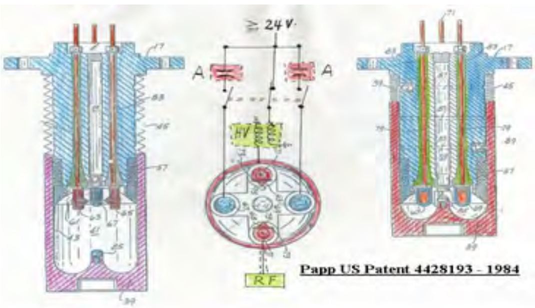

Figure 1: Engine cylinder configuration of Joe Papp noble gas engine

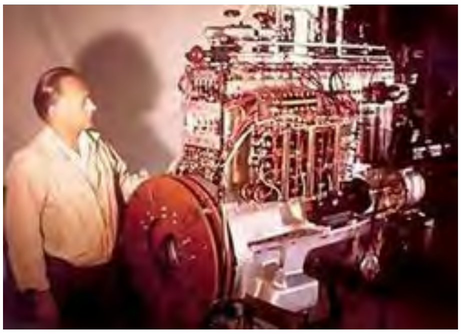

Figure 2: Joe Papp pictured next to engine

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Estimation of bubble fusion requirements during high-pressure, high-temperature cavitation

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Taleyarkhan's group at Oak Ridge National Laboratory (Tennessee, USA) have claimed to have found evidence of nuclear fusion in a beaker filled with an organic solvent subjected to ultrasonic irradiation [1,2]. More recently, Toriyabe et al. [3] investigated the possibility of fusion reactions occurring during ultrasonic cavitation (UC) in a liquid Li target irradiated with a deuteron (*d*) beam. Although no meaningful bubble fusion events were detected, extremely large enhancements of $d + d$ reactions were occasionally observed. The bubbles produced by UC, a technique commonly employed in sonochemistry, are typically several micrometers in size, and their collapse can generate microjets with temperatures of several thousand degrees Celsius. In contrast, bubbles produced by water jet (or liquid jet) cavitation methods, such as floating cavitation, are several hundred micrometers in size, and their collapse produces microjets with high pressures of approximately 1.0 GPa.

For many years, fusion reactions have been used to raise the temperature of plasmas to investigate several aspects of this state of matter, including the external energy required to increase the temperature of a plasma, the conditions of a plasma at its critical point, and deuterium–tritium (D–T) reactions. It has been found that, for nuclear fusion to occur, it is necessary for the original nuclei to collide at a speed of over 1.0×10^3 km/s. Thus, the nuclei must experience a pressure of 1.0×10^{11} atm and a temperature of 1.0×10^8 °C.

In the present study, a new cavitation method termed multifunction cavitation (MFC) [4-7], which combines the characteristics of both UC and water jet cavitation, was applied to the study of bubble fusion. This method involves irradiation with ultrasonic waves to achieve low-velocity floating cavitation. The cavitation velocity and the pressure and temperature inside a bubble in deuterated acetone when employing MFC were estimated theoretically and compared to the values required for fusion.

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Hydrogen reactor for Rydberg Matter and Ultra Dense Hydrogen, a replication of Leif Holmlid

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Ultra Dense Hydrogen has until now never been detected outside the research group of Gotenborg University lead by Professor Leif Holmlid. We hereby present a reactor setup that converts Hydrogen to Rydberg matter, dense and ultra dense state of Hydrogen to be used in energy systems. Ultra Dense Hydrogen is releasing particles which can be one of the experimentally possibilities to explain LENR.

Ordinary Rydberg matter H(1) is a condensed phase of interacting Rydberg species of atoms and molecules, which can condense to form dense and ultra dense states of Hydrogen D(0) with bond distance of 2,3+/-0,1pm in a reactor setup. The current experimental reactor builds on the research reactor on Ultra Dense Deuterium used by Prof Leif Holmlid at the University Of Goteborg. Ultra dense hydrogen is of extreme importance for fundamental reasons but also as fuel with the highest energy content of any combustion fuel, target material for laser initiated inertial confinement fusion and for the production of high energy particles. Several experimental setups has been successfully demonstrated to produce Rydberg Matter (Badiei & Holmlid, 2006) and ultra dense states of Hydrogen (Olofson & Holmlid, 2012) at the University Of Gøteborg by the research group of Professor Leif Holmlid but this is the first highly successful reactor design outside the University. Here we describe an efficient emitter holder, system and reactor design for applied physical purposes to produce Rydberg Matter and ultimately ultra dense states of hydrogen. A emitter holder is produced with the flexibility of being implemented into any reactor design for future research and development into ultra dense hydrogen. We show how the system operates and is used to monitor Rydberg matter and condensed hydrogen states.

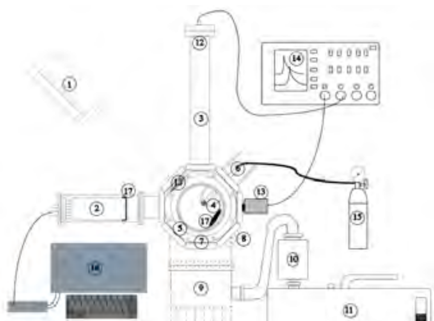

Figure 1. Experimental reactor for Rydberg and Ultra Dense Hydrogen showing YAG laser (1), (2) Photonelectron multiplier, (3) time-of-flight tube TOF, (4) Emitter, (5) vacuum chamber, (6) gas and electrical feedthrough, (7) adjustable substrate stage, (8) temperature probes, (12) TOF detector.

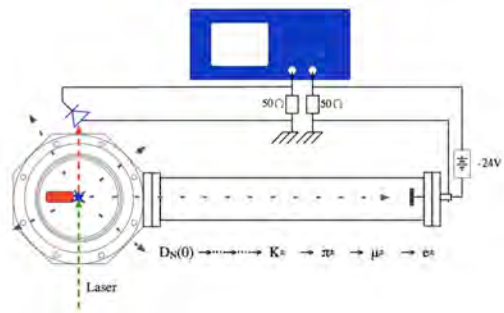

Figure 2. Time Of Flight setup for the detection of charged particles emitted from Ultra Dense Hydrogen.

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Distance dependency of spontaneous decay signal from ultra dense hydrogen source

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Ultra dense hydrogen has been reported to emit spontaneous high-energy particles, Kaons, Pions and Muons [1][2][3][4]. Kaon decays to Pions with a lifetime of $(1.2380\pm0.0021)\times10^{-8}$ s and Pions decay to Muons with a lifetime of 2.6033×10^{-8} seconds. Some of Leif Holmlids work has been replicated in Oslo using his advice and similar setup. The aim of this work is to study the distance dependency of the spontaneous signals from a ultra dense hydrogen source.

There are no published reports by Leif Holmlid were the distance behavior of the signal from an ultra dense hydrogen source has been studied in detail at longer distances. A custom-built experimental setup was assembled with two different multichannel analyzers attached to the same photoelectron multiplier fitted with muon converter [1] [5]; here we report measurements from different distances to an ultra dense hydrogen source.

Figure 1: Movable detection equipment to measure spontaneous signal from a ultra dense hydrogen source.

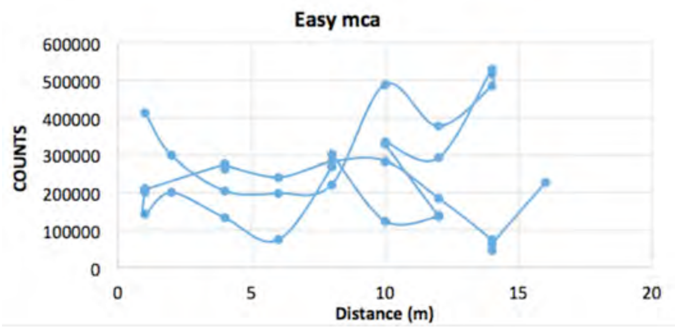

Figure 2: Distance dependency of spontaneous decay signal from an ultra dense hydrogen source. First showing a decrease in counts from 0-8 m then a increase in counts from 8 to 15 m. When moving the detector closer to source we can see the same behaviour. Some fluctuations does occur possible due to time variations from first measurements.

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[2] Holmlid, L., & Olafsson, S. (2016). Charged particle energy spectra from laser-induced processes: Nuclear fusion in ultra-dense deuterium D(0). *International Journal of Hydrogen Energy*, *41*(2), 1080–1088. https://doi.org/10.1016/j.ijhydene.2015.10.072

[3] Holmlid, L., Olafsson, S., & Science, A. (n.d.). Detection of muons and neutral kaons from ultra-dense hydrogen H (0) by lepton pair-production, (0), 1–34.

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Pulse shape and PMT stabilization period from spontaneous signal from a ultra dense hydrogen source

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Ultra dense hydrogen has been reported to emit spontaneous high-energy particles, Kaons, Pions and Muons [1][2][3]. Kaon decays to Pions with a lifetime of $(1.2380 \pm 0.0021) \times 10^{-8}$ s and Pions decay to Muons with a lifetime of 2.6033×10^{-8} seconds. Some of Leif Holmlids work has been replicated now in Oslo using his help and advice for building similar setup.

In this work we present study of the pulse behavior of the spontaneous signal as detected by assembly of Photomultiplier tube PMT and muon converter [2], similar to Leif Holmlid design. We have detected distribution of multiple peaks very close in time in the raw signal. The multiple peaks appear always very close in time, the shaping amplifier integrates them often together in one larger peak that affects the interpretation of resulting spectrum greatly. This has not been discussed by Leif in his published papers and first attempt of comparison with his spectra and new will be performed and how it affects the high energy particle conclusion.

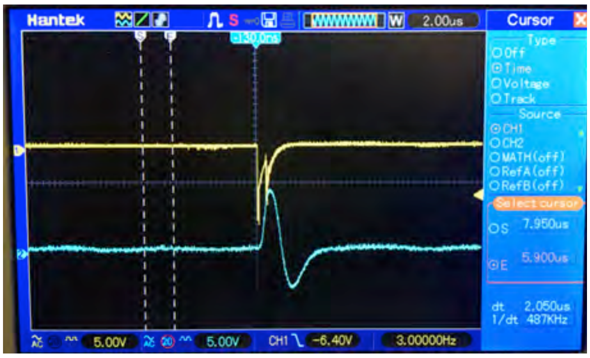

Figure 2: PMT + fast preamplifier raw signal (yellow) showing double pulse possibly from one or two particles interacting with the muon converter and the PMT, the shaping amplifier (blue) integrates these two events to a single event.

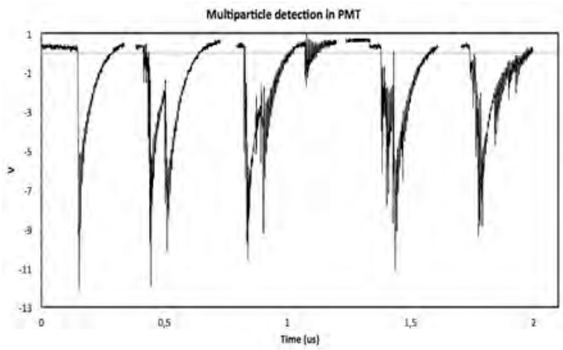

Figure 1: A collection of different PMT + fast preamplifier raw signal events showing varying number of close evennts in time. multiple peaks when PMT is close to Ultra Dense Hydrogen Source.

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Experimental on hydrogen carrying metal glow discharge

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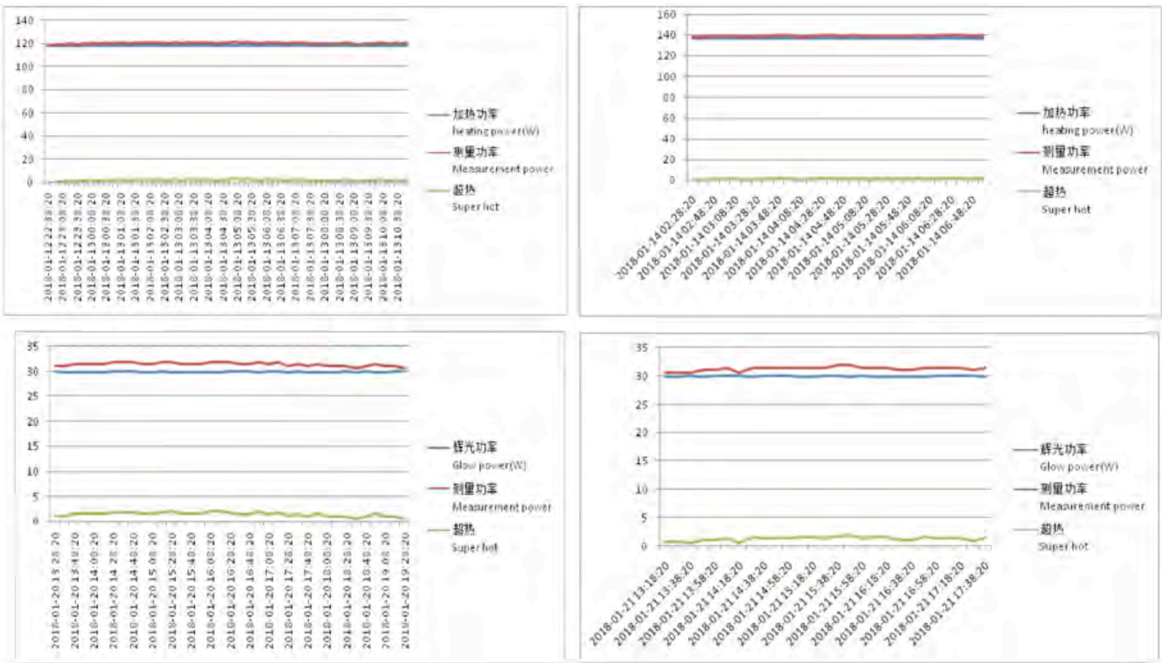
Following Prof. Mizuno Tadahiko's work [1] a new Ni-D gas glow discharge system has been developed with emphasis on amount of heat exchanger. The main results are:

(1) **Reliable:** The amount of heat exchanger are reliable during whole process, because they are checked before and after run. The abnormal thermal effect was found in the glow discharge state and heating state..

(2) **Reproducible**: The results are reproducible, because the abnormal thermal effect was measured four times in the 12 day experiment.

(3) **Safe**: There is no radiation above the back-ground level detected.

This is the four anomalous of effect power data chart, the red line is the measurement of power, blue line is the input power, the green line is the anomalous of effect power, it can be seen that the output power measurement is greater than the input power, the amount of heat accumulated over 65KJ.



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Detecting Charged Particles in LENR Applications using CR-39

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Abstract

CR-39 was used in LENR nanoparticle experiments to investigate the emission of energetic charged particles. The experiments utilized hydrogen (or deuterium) absorption in palladium-zirconium nanoparticles. Calibration for the CR-39 surface morphology response to the particle's energy and mass was done using a linear accelerator allowing for energy spectroscopy. An automated imaging platform combined with machine learning image recognition software was used to efficiently scan samples and consistently detect particle tracks. Using these methods, a direct relationship was found between track density and number of absorption-desorption cycles. Trends between track density and other parameters are also being investigated, e.g. pressure, gas type, location in nanoparticle vessel, etc. Results from these trends and their relationship to experimental parameters will be discussed.

Electron Quasiparticle Catalysis of Nuclear Reactions

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Abstract

We present a model based entirely on known, conventional physical chemistry, solid state physics and muon catalyzed reaction physics, the combination predicting both the isotopes observed and the lack of known energetic emissions for a set of proton-nickel and related reactions. The model unifies the observation of a new reaction type recently discovered in surface catalysis and the observation of the cryogenic, chemically-induced fusion reactions of muon catalyzed fusion. Unification depends on the use of a third, negative particle between reactants having an effective mass above a threshold. A solid state physics discovery provides a transient, elevated effective mass electron quasiparticle created by simultaneous addition of electron energy and lattice crystal momentum for placing the quasiparticles near an inflection point of the band structure of the material, where effective mass diverges. Observations suggest in every case of anomalous isotope and energy emission a mechanism appears to exist to add such crystal momentum and energy, sufficient to raise the effective mass above a calculable threshold. Applications include transmuting radioactive waste into natural elements.

Transmutations by Heavy Electron Catalysis

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Our model uses heavy electrons to facilitate nuclear reactions, similar to muon catalysis. The heavy electrons have lifetimes ~ 10 fs, during which some of them may facilitate nuclear transmutations. The model is described in a separate paper. Here we compare predictions of the model with various experimental observations.

(1) Reactions of light hydrogen with Ni^{62} and Ni^{62}. These are claimed to have produced 11% iron, 10% copper and lesser amounts of zinc and cobalt. (Bazhutov-2014)

(2) Reactions between LiAlH4 and natural nickel. These depleted Li^{7} and all Ni isotopes except Ni^{62}. The reaction created many isotopes, in approximately decreasing amounts: Fe, C, O, Cl, Si, and smaller amounts of Cr and Mn, and apparently no copper, cobalt or zinc. (Levi-2014)

(3) Electrolysis of thin (65 nm) Ni films in light water with 1 molar lithium sulfate. These reactions produced silver (Ag^{107} and Ag^{109}) as well as Fe, Cu^{63} and isotopes similar to observations (1) and (2) above. (Miley 1996)

(4) Exploded Titanium foil produced Fe, isotopes. High voltage and current pulse vaporized titanium foil in either light or heavy water, producing Fe, Ni, Cu, Zn, and Co. (Urutskoev-2004)

(5) Deuterium diffusing through Cs, Sr, Ba, and W films on Pd (Iwamura)

(6) The reaction products were in the ground state (non-radioactive). Energetic emissions associated with dd fusion were not observed, except possibly as tiny traces

(7) Liquid neon that was dissolved in the liquid H_2/liquid D_2 mixture prevented muon catalyzed fusion reactions.

8) Weighable amounts of new isotopes have been reported, with substantial excess heat.

9) Darkening of photographic plates. X-rays and low energy gamma (~ 200 keV) have been observed, but energetic particles emitted are apparently not charged, except for trace amounts.

Heavy electron catalysis may be useful for neutralizing Cs^{137} and Sr^{90}.