"Application of a piezo sensor matrix for in situ, real-time characterization of low energy nuclear events."

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An experimental design is presented which includes a high-throughput technique for identifying environmental conditions and material surface morphologies responsible for Low Energy Nuclear Reaction (LENR) active sites." LENR active sites occur at discreet morphologies on the surface of a substrate, becoming activated, releasing heat and then self-destructing in a high energy event.

A simple piezo sensor matrix is applied in intimate contact with the LENR active substrate to identify the location of active sites as well as monitor their characteristics over time. Location and quantification of active sites and active site events is achieved by calibrating and characterizing sound and heat wave propagation values in the system. De-convolution algorithms based on wave propagation and triangulation can accurately determine point sources of heat and sound waves, allowing for monitoring of active sites in real-time. Pre-experiment analysis with SEM can identify the morphology responsible for active site creation while post-experiment analysis with SEM and XRF can confirm the presence of active sites and craters or transmutation products.

This low cost, real-time system can be used in tandem with SEM/XRF to rapidly screen material samples for the production of anomalous heat and active site events. Due to the real-time nature of the technique, environmental variables and triggering mechanisms can be rapidly investigated to determine optimal conditions for activation and control of LENR active site events.

High Energy D_2 Bond from Feynman's Integral Wave Equation

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Chemical bonding is a well understood quantum phenomena with the accuracy of Schrodinger based predictions determined by the computing power applied [1]. The hydrogen molecule ion, H_2^+, is the most studied and theoretically understood molecule, with no unexplained observations. Thus, to understand how two deuterons could possibly fuse to ^{4}He, a more fundamental approach than the Schrodinger equation is possibly required. The general approach used in nuclear physics might be appropriate, which generally begins with the Lagrangian of the particle interactions. From the Lagrangian, a solution to Feynman's path integral is sought; often evolving to the more familiar Schrodinger equation. This generally requires many assumptions and or approximations to arrive at a reasonable solution. Applying this technique to the relatively simple deuterium molecule ion, D_2^+, would seem a reasonable starting point. The masses and forces on each particle are well known and for the most part non-relativistic, so it just remains to search for an unexplored region in the solution space.

In this work the previously unexplored region of the Lagrangian will be shown to be the maximum of the action integral, instead of the minimum action of orbital mechanics used to predict the well known electron behaviour describing chemical properties. Generally in physics it is the *'principle of least action'* that is considered. At the atomic level the principle of least action is not a necessary condition for an observable in a system of particles. The necessary condition is a classical solution to the Lagrangian action; an '*extremum*', as emphasized by Feynman [2]. It is this extremum which predicts the build up of probability of possible paths, making an observable state possible.

By restricting the three particles of the D_2^+ molecule ion to a co-linear path (one-dimension), a classical bond can be demonstrated between two deuterons mediated by an electron. Classical in this context means motion as predicted by Newtonian mechanics from initial conditions, velocity and position, and the electrostatic forces between the particles. The one-dimensional classical like behaviour of the high energy electron, with a long path length, is very similar to high quantum number conditions familiar to our macroscopic experience. A classical closed path with the deuterons orbiting each other can be inferred from this model, with the electron oscillating along the axis through the two nuclei. A *perfect* classical path will be shown to exist as a maximum of the action, however unstable. Using the classical path as a starting point, mathematical techniques clearly outlined by Feynman and Hibbs [2] allow for a straight forward quantum analysis. This analysis predicts a bond between the deuterons of ~30keV.

The same result can be derived starting with the Schrodinger wave equation. This approach can be interpreted as diffraction of solid-state electron waves giving an additive interference pattern between two closely spaced deuterons (<0.1 angstrom). Although the result is the same, the intuitive notion of the origins of the state, are not as convincing as Feynman's approach.

Using this High energy bond as a starting point, it is straight forward to derive a mechanism of degenerate states evolving in time. These degenerate states yield energies consistent with reported LENR reactions. The possible pathways to [tr+p], [^{3}He+n], [^{4}He gamma+or electrons], are all considered, with the products determined by the quantum kinetics. The result is predominantly ^{4}He, with energy dissipation through ~1keV electrons, ppm tritium and no neutrons, consistent with experiments.

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Calorimetric & Nuclear Diagnostic of Anode Plasma Electrolysis

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It was continued the investigation of plasma electrolysis with anode gas discharge. Voltage as earlier was (200-600)V. Current amplitude was (1-10)A. The electrolyte composition was (5-10)M NaOH & 2M Na_2CO_3 in usual water. Nickel foil (0,1 x 50 x 100 mm^3) was used for cathode & Tungsten or Niobium rod (Ø6mm) was used for anode.

For receiving experimental results there were used following diagnostic methods: 1)Thermocouple calorimetry; 2)Tritium scintillation diagnostic in electrolyte; 3)Erzions flux generation with help of radiometer "Kran" & 2 dozimeters "Sosna", 4)Scintillation diagnostic (CsI & NaI) of γ-radiation, 5)Neutron diagnostic with He^3 counters, 6) Photo emulsion & Plastic Solid State Detector tracks diagnostic.

Received results are discussed.

Investigation of Radiation Effects in Water Solutions During Exposure with Laser or LEDs Light

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The installation for gamma-, X-ray and neutron registration in water solutions (600 ml LiOH, or NaOH, or Na_2CO_3) during exposure with red light (λ=645+/-20 nm) of laser or light-emission devises (LEDs) was created. The laser light power was 5 mW and the LEDs – from 600 mW up to 10 W.

Neutrons were measured with help of tow ^{3}He counters, placed in paraphine barrel. Small neutron emission (up to 100 neutrons) has been registered in the form of series of short (ms) bursts during some minutes. Tritium production has also been detected in water solution probes. The gamma-ray and X-ray radiation measured by NaI scintillation detector & Geiger counters was not detected.

Received results are discussed.

Erzion Interpretation of Our Experimental Results with Light, Heat and Plasma Stimulation of Cold Nuclear Transmutation

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It is presented the Erzion model for theoretical explanation of the generation of excess heat, new chemical elements and isotopes production, X, β, γ-ray and neutron radiation in our experiments with light, heat & plasma stimulation of Cold Nuclear Transmutation processes.

It is proposed suggestions for intensification of these experimental results.

High temperature and high pressure plasma electrolysis experiments

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Ohmori et al. (1), then Mizuno et al. (2,3) showed in high voltage-high current electrolysis experiments the production of excess heat and abnormal production of hydrogen. Cirillo et al. (4) have shown transmutation of elements on the tungsten cathode during similar types of plasma electrolysis. Also, Fauvarque et al. (5) have shown the production of excess heat. All these experiments have been performed with light water at boiling temperature i.e. 100°C and atmospheric pressure. We have developed a new calorimeter that can operate at higher temperatures and higher pressures. The cell is of cylindrical shape made of Teflon 10 cm in diameter and 21 cm high. The cell is positioned on a balance in order to measure continuously the weight loss of the cell during operation. The tungsten cathode of various diameters is located at the center of the cell, and the anode is a stainless steel foil surrounding the cathode. A mechanical pressure gauge permits the measurement of the pressure of the cell. The temperature is calculated from the pressure-temperature boiling curve. A calibrated relief valve keeps the pressure constant in the cell. The electrical input power is measured by a high-speed wattmeter, and the heat produced is calculated from the weight loss of the cell. The cell is also equipped with a resistor for calibration of the system, and heating the water to boiling prior to the start of the electrolysis.

At the conference we will give the new results showing the influence of the pressure and the temperature to the excess heat.

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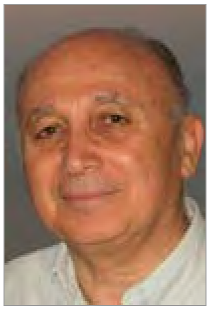
Biography

Jean-Paul Biberian



Jean-Paul Biberian graduated as a nuclear and electronics engineer from Nancyin 1969, he got his PhD in Physics from the University of Paris in 1975.

He is a specialist of surface structures. Twice he stayed at the Lawrence Berkeley National laboratory in 1976-1979 and again in 1992-1995 where he worked on catalysis. Even though he is still continuing to collaborate on surface science, since 1993 he concentrates on experimental work on Cold Fusion. In 2004 he organized ICCF11 in Marseilles. Last year he published the first book on Cold Fusion in French. He is the editor in chief of the electronic journal : The Journal of Condensed Matter Nuclear Science.

Hydrogen Embrittlement and Piezonuclear Reactions in Electrolysis Experiments

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Abstract

Several evidences of anomalous nuclear reactions occurring in condensed matter have been observed during electrolysis, solid fracture and liquid cavitation. Despite the great amount of experimental results coming from the so-called Cold Nuclear Fusion and Low Energy Nuclear Reaction research fields, the comprehension of these phenomena still remains unanswered. On the other hand, as reported by most articles devoted to Cold Nuclear Fusion, one of the principal features is the appearance of micro-cracks on the electrode surfaces after the experiments. In the present paper, a mechanical explanation is proposed considering a new kind of anomalous nuclear reactions, the piezonuclear fissions, which are a consequence of hydrogen embrittlement of the electrodes during electrolysis. Energy emissions in the form of neutrons and alpha particles were measured during the experiments, where the electrolysis was obtained using Ni-Fe and Co-Cr electrodes in an aqueous solution. The electrode compositions were analyzed both before and after the experiments recognizing the effects of piezonuclear fissions occurring in the host lattices.

Piezonuclear Fission Reactions Simulated by the Lattice Model

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Abstract
Recent experiments conducted on natural rocks subjected to different mechanical loading conditions have shown energy emissions in the form of neutrons and anomalous chemical changes ("piezonuclear fission"). In the present study, we have used a numerical technique to simulate the anomalous nuclear products of piezonuclear fission. Specifically, the reactions were simulated by means of a nuclear lattice model that assumes that nucleons are ordered in an antiferromagnetic face-centered-cubic (fcc) array. The simulations indicate that small and middle-sized nuclei can be fractured along weakly-bound planes of the lattice structure. We argue that the simulations provide theoretical support for the experimentally-observed reactions and, moreover, that the probabilities calculated for various low-energy fission phenomena can be used to explain the stepwise change in abundance of elements in the Earth's crust, which is known to have evolved from basaltic to sialic composition over geological time.

Further progress/developments, on surface/bulk treated Constant wires, for anomalous heat generation by H_2/D_2 interaction

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In the framework of those studies aimed to analyze anomalous effects (thermal and/or nuclear) due to the interaction among some specific materials (pure and/or alloys) and H_2 (or D_2), we focused, since 2011, on a specific alloy called Constantan (Cu_{55}-Ni_{44}-Mn_1). We selected such material using our own considerations and intuitions and because, according to a scientific paper [1], it has the largest energy value for dissociation of H_2 to 2H, i.e. about 3eV. Among others B. Ahern suggested that Ni-Cu-H can be used for heat generation. We improved the preparation procedure of such wire from simple thermal treatments (up to May 2012 [2]) to more sophisticated ones, with more tight control of the multilayered (400-700) surface structures. Some of the results were presented at ICCF17, Aug. 2012 [3]. After [3], several groups asked to make their own experiments using such kind of wires (Φ=200µm, l=100cm) to cross-check (and possibly improve) our results. Some of such Researchers (group of M. Fleischmann Memorial Project; U. Mastromatteo) made public their (positive) results since Dec. 14, 2012 at Ministry of Aeronautics in Rome, Italy. In short, using an (home-made) apparatus integrated with an acquisition system (type PXi) by National Instruments, we made, since September 2012, not mentioning qualitative reconfirmation of previous results, further and unexpected progress and discoveries:

a) We developed a new kind of procedure of measurement (about anomalous excess heat) under dynamic vacuum, to avoid the effect of different thermal conductivity, inside the gas cell, due to type of gas and pressure variation: the wire didn't lose, macroscopically, H even at T=600°C.
b) We developed a new, very simple, type of surface coating (2 layers) that is nano-diamandoids like;
c) We observed, at least 2 times, the phenomenon of water splitting due to catalytic effect of surface treated Constantan. Such phenomenon is larger in comparison with what expected just by thermal splitting (wires temperature of about 300-500°C);
d) We observed a very large variation (about a factor 100) of Resistive Thermal Coefficient (RTC) of the wire used (400 layers) as the amount of H (related to the macroscopic value of resistive ratio R/Ro, normalize to empty wire Ro) increased. As example, with "treated" virgin wire (w/o H_2) the RTC was about $5*10^{-6}$ and increased to $6*10^{-4}$ when the R/Ro reduced to 0.68; temperature range 20-300°C. The RTC is larger with D in respect to H. Experiments are in progress also at 77K.
e) Overall results are affected by previous operating conditions

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Celani's Wire Excess Heat Effect Replication

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Abstract:
This paper presents the results obtained during the replications of Francesco Celani's experiments made by the Martin Fleischmann Memorial Project (MFMP). In his experiments Celani saw consistent and reproducible excess heat generation results coming from treated constantan wires using different protocols [1,2].

The design of the cell, which is based closely on the original experimental apparatus demonstrated at ICCF 17 is described in detail, with attention to the material choices and design geometry and its operating conditions. Differences between the original experiment and later replications that improved credibility are explored.

Using this processed material [3], two different protocols similar to Celani's work are shown in various apparatus in multiple geographic locations. The first protocol shown is similar to that presented at ICCF 17 [2] ; whereas a second improved protocol is shown that was later defined by Celani et al. [1]. Additionally researchers at MFMP utilized another identical dummy cell in order to keep the calculation baseline consistent with real-time changes of the labs environment.

Characterization of the wires is made before and after the experiment using scanning electron microscopy and electron dispersive spectrometry. Multiple calculations of the excess power are presented. The first one is derived by comparing active cell output to a baseline extracted from steady state calibrations. The second one uses Stefan-Boltzmann black-body calculation in the same way that Pr. Celani is doing. A last one uses the unactivated cell as a reference.

The presentation that will be made during the conference will explore these results and discuss the validity of this type of experiment, calorimetry and wire treatment for the production of excess energy.

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Simulation of the Nuclear Transmutation Effects in LENR

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LENR phenomena begin with a still poorly-understood entrance of a fermion/boson into the nuclear interior. One such mechanism – the thermal neutron-induced fission of uranium – was discovered in 1938 and subsequently revolutionized global military conflict and international politics [1]. Modern research indicates the reality of *multiple* LENR mechanisms in small and medium-sized nuclei [2], promising another revolution in energy production. Conceptually, LENR implies an expansion of the "central dogma" of the dynamics of atomic systems, ca. 1932, to a dogma that includes a mechanism of nuclear excitation by particles that enter the nucleus through the atom's own electromagnetic periphery [3] (the solid arrow): Neutrons ⇦ ⇨ Protons ⬅ ⇨ Electrons

While the production of radiation-free heat is the focus of most technological developments in LENR, the unambiguous demonstration of specifically *nuclear* effects remains an essential step for the acceptance of LENR into mainstream physics. For this reason, we have concentrated on the theoretical explanation/simulation of the nuclear transmutation effects reported in the LENR literature [2, 4]. In chronological order, we have previously simulated: (i) the asymmetrical fission fragments produced by the thermal fission of uranium and plutonium [5], (ii) the LENR transmutation products detected on palladium cathodes [3], and (iii) the recently-reported [6], *anomalous* asymmetrical fragments from the spontaneous fission of ^{180}Hg [7] (for which both the shell model and the liquid-drop model predict symmetrical fragments [6]).

In the present study, we have undertaken simulations of the "anomalous" products that have been measured in "piezonuclear fission" experiments on non-radioactive rocks, such as granite and marble, e.g., [8]. The experimental data on isotopes and neutron radiation have been reported by Carpinteri and colleagues in 12 publications in refereed physics journals (2009~2012) and the lattice model and simulation technique have been reported by Cook and colleagues in 30 publications in refereed physics journals (1976~2011). In brief, the essential theoretical argument is that the complexities of nuclear structure theory can be succinctly summarized within a specific nucleon lattice, which can then be used to make predictions concerning nuclear structure and nuclear reactions, i.e., a quantitative theory of the nucleus, quantum nucleodynamics [9]. With regard to piezonuclear fission, the lattice structure for ^{56}Fe necessarily contains a set of lattice planes along which fracture can occur. By calculating the binding energy along each lattice plane, the probability of producing various fission fragments can be determined. The dominant products from the fission of ^{56}Fe were symmetrical: ^{24}Mg, ^{27}Al and ^{28}Si. A full report of the simulation will appear in [10].

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Quantum Nucleodynamics (QND): The theory underlying the lattice simulation of LENR transmutations

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In the first half of the 20th century, a quantitative explanation of atomic structure (quantum electro-dynamics, QED) was created based on the *known* Coulomb force and a wave-equation, where integral quantum numbers are used to define all possible *electron* states (Eq. 1):

$$\Psi_{n,l,m} = R_{\,n,l}\,(r)\;Y_{m,l}\,(\theta\,,\phi) \qquad \text{Eq. 1}$$

The energy states of electrons are given by unique combinations of $\boldsymbol{n}$=1, 2, …; $\boldsymbol{l}$=0, 1, …, $\boldsymbol{n}$-1; $\boldsymbol{m_l}$ = -$\boldsymbol{l}$, …, -1, 0, 1, …, $\boldsymbol{l}$; and $\boldsymbol{m_s}$ = ±1/2. The sequence and occupancy of allowed states can be stated as the Periodic Table and the energy of electron transitions can be calculated precisely in QED.

In the second half of the 20th century, a ***nuclear*** version of the wave-equation (Eq. 2) led directly to the nuclear independent-particle model (IPM), where all possible *nucleon* states were defined by:

$$\Psi_{n,j\,(l+s),m,i} = R_{\,n,j\,(l+s),i}\,(r)\;Y_{m,j\,(l+s),i}\,(\theta\,,\phi) \qquad \text{Eq. 2}$$

While many questions concerning the strong nuclear force remain unanswered, the quantal states of nucleons are given by: $\boldsymbol{n}$=0, 1, 2, 3, …; $\boldsymbol{l}$ = 0, 1, …, (2$\boldsymbol{n}$)/2; $\boldsymbol{j}$ =1/2, 3/2, …, (2$\boldsymbol{n}$+1)/2; $\boldsymbol{m}$ = -$\boldsymbol{j}$, …, -3/2, -1/2, 1/2, 3/2, …, $\boldsymbol{j}$; ***spin (s)*** = ±1/2; and ***isospin (i)*** =±1. The sequence and occupancy of allowed nucleon states in the IPM (Table 1) corresponds extremely well with empirical data.

<table>
<tr><td rowspan="5">Quantum Numbers</td><td>n</td><td>0</td><td colspan="3">1</td><td colspan="6">2</td><td colspan="10">3</td><td colspan="6">4</td></tr>
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Table 1: The quantum states of the first 100 nucleons in both the IPM and the fcc lattice model.

Interestingly, Wigner [1] showed that the entire pattern of nucleon states (Table 1) corresponds to the symmetries of a face-centered-cubic (fcc) lattice of nucleons – theoretical work that was explicitly acknowledged in his 1963 Nobel Prize citation. We subsequently showed how the fcc lattice can be considered to be the structural basis for QND [2-5] *based on the fact that all nucleon states and their transitions can be defined in terms of lattice coordinates* (x, y, z). Specifically:

$\boldsymbol{n}$ = (|x| + |y| + |z| - 3) / 2 $\quad$ $\boldsymbol{l}$ = (|x| + |y|) / 2 $\quad$ $\boldsymbol{j}$ = (|x| + |y| -1) / 2 $\quad$ $\boldsymbol{m}$ =|x| *$(-1)^{(x-1)/2}$/ 2
spin = $(-1)^{(x-1)/2}$/ 2 $\quad$ ***isospin*** = $(-1)^{(z-1)/2}$ $\quad$ ***parity*** = sign(x*y*z)

which leads to *the exact same (sub)shell states and occupancies* as found in the IPM (Table 1).

We have used the identity between the IPM and the fcc lattice to explain LENR findings on transmutations [4-7]. In the present talk, we show how the nucleon lattice can be considered as the structural basis for QND – and represents a return to a realist, non-Copenhagen interpretation of quantum mechanics [8, 9] à la Einstein and Bohm, while producing the same computational results.

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Numerical modelling of hydrogen/deuterium absorption in transition-metal alloys

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Experimental investigation of anomalous heat effects from hydrogen isotope absorption in palladium lattice has proven to be an arduous task. Numerical modeling of the electronic structure of the Pd-H(D) system holds out the promise of identifying LENR active materials.

Multiple theories on hydrogen isotope fusion in Pd metal have been developed over the years. Among other important factors, the high concentration of H(D) atoms and their close proximity to each other within a host lattice are important. We use numerical modeling to investigate conditions favorable to lower H-H (D-D) separation. This separation depends on the background charge density within the lattice [1, 2]. Because of the high charge density in bulk Pd the internuclear distance between two hydrogen or deuterium atoms is larger than the value in vacuum [1]. However, the presence of lattice defects (vacancies [3], free-internal surfaces/cracks [4] and interstitials [5]) can lower the charge density down to the level which would promote the $H_2(D_2)$ molecule formation at closer separation.

We use the open-source software package QuantumEspresso to investigate $H_2(D_2)$ absorption in transition-metal alloys in the presence of different types of lattice defects and dopants. In addition to the previously reported effect of vacancies in Pd lattice [3], we find that doping the transition metals with elements of high electronegativity further lower the charge density and results in absorption of $H_2(D_2)$ with shorter separation distance.

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Anomalous Heat Induced by Deuterium Flux in a Bunch of Long-Thin Palladium Tubes using PID Method for Calorimetry

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In 15 year continuous experiments, gas-loading deuterium-palladium system has evolved from a long-thin palladium wire to a bunch of long-thin palladium tubes (Fig. 1). Calorimetric analysis has evolved from high precision Seebeck micro-calorimeter (C-80) [1] to a high precision digital power supply controlled by a PID system. Triggering mechanism has evolved from pumping outside the palladium tube to pumping inside the palladium tubes. The pure palladium wire has evolved to quaternary alloy tubes (Pd-Ag-Au-Ni). Anomalous heat has been induced by a deuterium flux through the thin wall of the palladium tubes. It lasted several hours. It manifested itself as a spontaneous oscillation of temperature with an exponentially growing amplitude first (Fig.2). The maximum temperature has been extended from 120^0C to 150^0C. A flow-calorimeter is going to apply for confirmation of this anomalous heat effect.

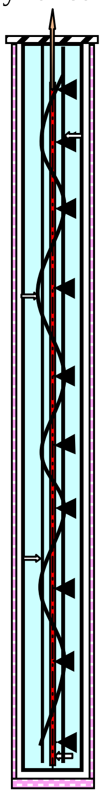

Fig.1

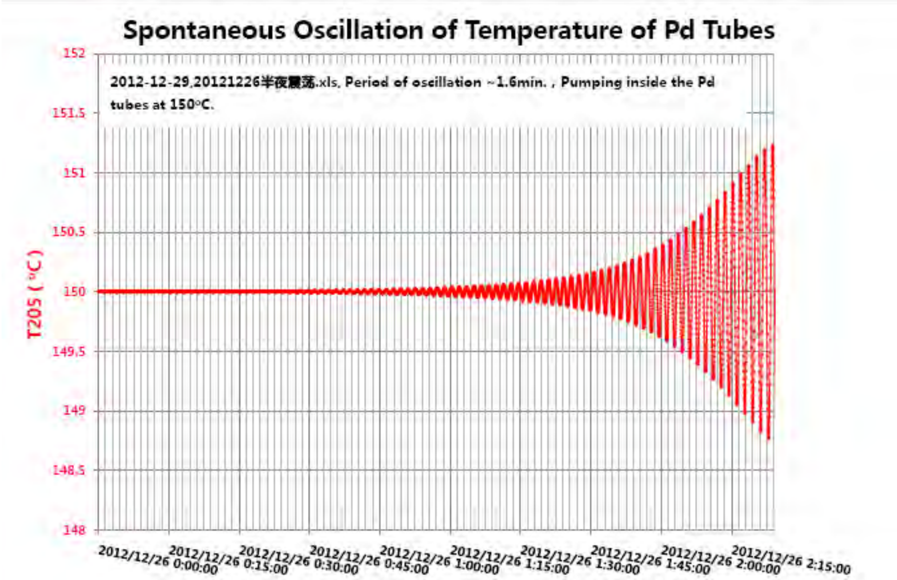

Fig.2 a spontaneous oscillation of temperature with an exponentially growing amplitude

This anomalous heat effect in deuterium-palladium has a positive temperature coefficient. It would have had driven the system unstable if there had been no PID controlled power supply

An anomaly in the Ni-Cr heating wire has been identified in the deuterium gas after heating around 150^0C. It appears as a negative temperature coefficient of electrical resistance with anomalously large magnitude. This heating feature constitutes the seeds of a spontaneous oscillation of temperature.

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Biography

Robert V. Duncan, Ph.D.
Vice Chancellor for Research
Professor of Physics
University of Missouri

Robert Duncan joined the University of Missouri as the Vice Chancellor for Research in August, 2008, accepting responsibility for MU's research enterprise, including $235 million+ per year in contracts and grants, and over $200M in research-related fee-for-service activities. He also supervises MU's research administration and its major research facilities, including the largest research reactor in academia that supplies more radioisotopes for medical applications than any other reactor in the USA, multiple interdisciplinary research centers, and associated economic development and technology licensing and incubation efforts.

Duncan received his bachelor's degree in physics from MIT in 1982 and his doctorate in physics from the University of California-Santa Barbara in 1988. He has served as a professor of physics and astronomy at the University of New Mexico (UNM), as a visiting associate on the physics faculty at Caltech, as a joint associate professor of electrical and computer engineering at UNM, and as the associate dean for research in the College of Arts and Sciences at UNM.

R. V. Duncan has published extensively in experimental low-temperature physics, including the observation of new phenomena near the superfluid transition in helium, and in new instrumentation development. Previously, Dr. Duncan has served as principal investigator on a fundamental physics research program for NASA. As the former Director of the New Mexico Consortium's Institute at Los Alamos National Laboratory, he has worked to fund major conferences and summer schools in quantitative biology, information science and technology, energy and environment, and astrophysics and cosmology. To date, Duncan has received more than $8 million in funding from various sources on research efforts that he has led as Principal Investigator.

Dr. Duncan is a Fellow and a life member of the American Physical Society. He was named the Gordon and Betty Moore Distinguished Scholar in the Division of Physics, Mathematics, and Astronomy at Caltech in 2004, and he chaired the Instrumentation and Measurement Topical Group for the American Physical Society in 2002, and the International Symposium on Quantum Fluids and Solids in 2003. He has consulted extensively to industry, and co-invented and assisted in the formation of companies. Duncan chaired the Decadel Survey Panel of the National Academy of Sciences on Fundamental Physical Sciences in Space, which has been released as Chapter 8 within Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era through the National Research Council.

Neutron Isotope Reactions

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The field of low temperature nuclear reactions has made slow but steady progress. Evidence has accumulated for production of energy at the level of a few watts, for production of helium in proportion to energy, for energetic particles, and for transmutations of elements. But there is no generally accepted theory for these phenomena. Progress requires a body of experimental evidence and a candidate theory through which theory and experiment can gain mutual support and acceptance.

We explore the possibility that transfer of neutrons from neutron isotopes to ordinary nuclei, followed by beta decay of the neutron-enriched nuclei, facilitates a class of low-temperature transmutations. We have tested this possibility by comparing the implications of neutron isotope theory with the transmutations reported by Iwamura and associates. We find that experiment quantifies and supports the theory, and that theory clarifies and supports the experimental observations.

Possibility of tachyon monopoles detected in photographic emulsions

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Low-energy nuclear reaction experiments using photographic emulsions, including those by Urutskoev, *et.al* and Ivoilov, have shown unique particle tracks. Analysis of a sample population of these types of tracks suggests detection of magnetically charged particles with faster-than-light velocities. Particle kinetic energy was found from energy deposition and momentum was estimated from track curvature in magnetic fields. Measured values were plotted on a kinetic energy versus momentum graph and were found to fall in the v > c region. Track curvature was found to be parabolic, which is a signature for monopoles. Using the classical theory of tachyons, the plane of parabolic curvature suggests electrically charged tachyons detected as slower-than-light monopoles. Particle mass was computed, but is inconclusive. Further study is suggested to broaden this search.

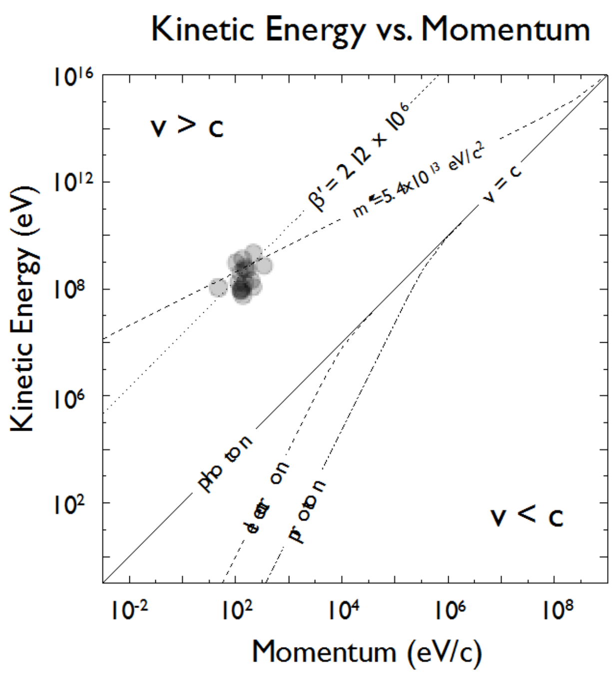

Fig. 1. Measured values for momentum and kinetic energy are clustered in the faster-than-light ($v > c$) area of the graph with a mass contour line at the peak mass value of 5.4×10^{13} eV/c^2 and a velocity contour line at $\beta' = 2.12 \times 10^6$.

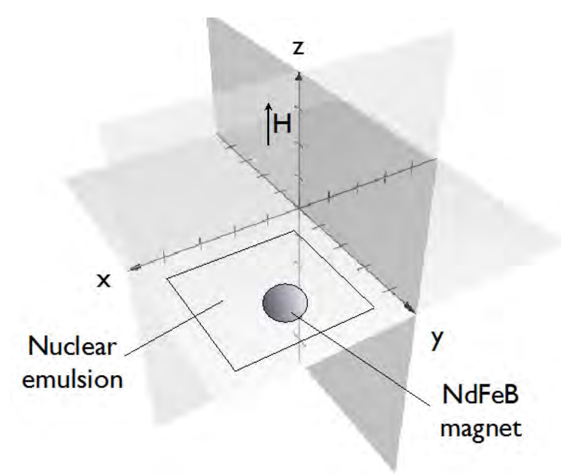

Fig 2. Experimental setup with applied magnetic field perpendicular to photographic emulsion.

Patenting Cold Fusion Inventions before the US Patent and Trademark Office

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The United States Patent Office - US PTO has developed a reputation for refusing applications directed to "Cold Fusion" technology. Past practices of the US PTO, which will be reviewed based on a published employee grievance hearing, have shown that some staff members have been hostile to granting patents in this field. However personal exchanges held with the US PTO in the fall of 2012 indicated that the US PTO *will issue* properly drafted patents which are directed to new technology in the field of Cold Fusion/generation-of-unexplained-excess-energy if accompanied by a proper disclosure and a demonstration that the asserted procedures will work as represented.

With the US PTO receiving over one half million applications a year, Examiners do not customarily require applicants to file proof that their alleged invention will work as represented. However, the US PTO has classified Cold Fusion and LENR technology in the same category as "perpetual motion". These are considered to be cases where there is doubt that the alleged invention will work. In these fields Examiners are expected to require applicants to demonstrate that the alleged invention actually works. To impose this requirement the Examiner must establish a basis for a legitimate doubt in a communication to the applicant before requiring applicants to provide proof of operability. Unfortunately, Examiners faced with Cold Fusion applications have in many instances used excessively negative and inflammatory language regarding the history of Cold Fusion science in attempting to place such a doubt on record.

Persons filing patent applications in this field have to be prepared to face a prove-it-works requirement. They do not have to prove that Cold Fusion works *per se*; they only have to prove that what they represent in their application is true. The disclosure accompanying their patent application must be sufficient to enable ordinary but knowledgeable workers in the field to reproduce what is promised in the patent application. This is not an area where a patent can be obtained on the basis of a prediction or prophetic insight.

The best procedure to follow in answering such a requirement from a US Examiner is to place the original patent disclosure in the hands of an independent agency that will follow the instructions in that document and report-back, hopefully, that they obtained the results as predicted in the patent filing. Such evidence may not rely on after-developed understandings or procedures but must be based on the original document as filed, together with publicly available knowledge existing as of that date. To address this limitation, applicants are advised to make multiple patent filings every time they develop new information that is important to exploiting the technology.

Before embarking on the considerable expense of filing patent applications, applicants should appreciate that their right to obtain patent protection is seriously constrained by what has already been done before. Under the new patent law in the United States, anything ever made "available to the public" anywhere in the world at any time before an applicant has filed their first patent application will count against that application and limit the scope of potential exclusive rights. Additionally, even if a patent is obtained, it may have to be limited to a novel feature that may not have commercial relevance. Care should therefore be taken to understand patenting procedures before spending unnecessary sums of money that will not prove worthwhile.

Cross Section Measurements of Deuteron-induced Reactions

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The results of the cross section measurements of deuteron-induced reactions $^{108}Pd(d,p)^{109}Pd$, $^{110}Pd(d,p)^{111}Pd$, and $^{110}Pd(d,n)^{111}Ag$ have been obtained at incident energies below the Coulomb barrier. The experiments were performed using a GE PETrace cyclotron with an external beam at the University of Missouri Research Reactor Center. The cyclotron is capable of delivering 60 mA of 8.4 MeV deuterons, with no more than 20 mA used in these experiments. The cross sections were obtained using a stacked-foil technique, utilizing titanium foil monitors. Experimental data are compared to published calculated cross sections and results discussed.

The progress of Celani’s experiment replication project in China

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Francesco Celani demonstrated his LENR device using H_2 gas and a specially treated constantan wire during the NIWeek 2012 and ICCF-17, showing a peak excess heat power of about 20W at an input power of 48W. Since then, a replication of Celani’s work has been launched through a project called MFMP (Martin Fleischmann Memorial Project) in an open method named “live open science” by the author. Thanks to the wire granted by Celani, a similar replication project is carried out at Delta Energy Technologies in China this year, aimed at observing significant amount of anomalous heat production as Celani did. The experiment setup is presented and the instruments are illustrated here. The methods of calorimeter are discussed and will be adopted in the experiment. The project progress is briefly introduced and the plan is shortly listed.

Verifications of LENR Observations in Nickel-Copper Alloy (Constantan) and Hydrogen Experiments

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Francesco Celani put on two apparently successful LENR demonstrations in August 2012. They involved nickel-hydrogen reactions using specially-prepared nickel-copper alloy (Constantan) wires and were based on earlier experiments by Celani [1,2]. Both demonstrations were supported by National Instruments (NI) in the form of integrated software and instrumentation.

Celani has shown a strong interest in having other investigators verify his LENR observations. To this end, he has provided samples of his treated Constantan wires to a number of other researchers for verification. NI continues to be supportive of Celani and others who are conducting Constantan-based nickel-hydrogen LENR experiments. A systematic study is underway to identify the various experiments and associated results achieved by investigators who have received Celani's Constantan wires. Preliminary results of the survey may be summarized as follows:

- The effect observed by Celani appears may not be as robust as initially indicated by the positive results in the demonstrations.
- Experiments to verify Celani's findings apparently should begin with replication (as closely as possible) of his equipment, materials, and procedures, followed by carefully adding variables after success (excess heat and/or reduction in electrical resistance) is achieved.
- It appears advisable to recalibrate the Celani reactor each time it is set up for experiments or demonstrations.
- Interpreting reduction in electrical resistance as an indication of hydrogen loading of the Constantan wire must be done carefully; other factors may also affect resistance changes.
- The metallurgy of nickel-copper alloys involved with treated Constantan wire may be more complicated than initially understood.
- Measurement of temperatures (by appropriate number and placement of sensors in and around the reactor) is a critical factor in interpreting results as excess heat.
- Care must be taken in interpreting results that appear not to verify Celani's observations – the cause may lie in an insufficiently similar experimental setup or procedure.

Analysis of experimental results by investigators of Celani's wires and methods continues and will include as many independent attempts at verification as possible.

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Modeling LENR Chemical Environments by Computational Chemistry

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There have been many studies of experiments with hydrogen or deuterium in metals reporting anomalous reactions, described as LENR or CANR or cold fusion. Understanding and optimization of the effect would be helped if testable hypotheses could be found that can account for the many remarkable anomalies. Here chemical conditions associated with the anomalies are modeled using standard ab initio computational chemistry software, so validity of the calculation method is transparent and replicable. Here models of LENR chemical environments suggest ways the anomalies can be triggered, optimized, and tested.

Possibility of LENR Occurring in Electric Arc-Plasma: Preliminary Investigation of Anomalous Excess-Heat Generation during Underwater Arcing using Industrial Electrodes

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In view of the growing number of reports in LENR literature that nuclear-reactions have been observed in a variety of experimental configurations, it was decided by the 'engineer *turned* physicist' author [1] to investigate the possible 'generation of anomalous excess-heat during underwater arcing'. A rough calorimetric heat-balance 'accounting' in underwater welding experiment [2] is done considering water heating, latent-heat of evaporation and visible radiation-loss. The initial underwater-welding experiments conducted in 2010, revealed that around 30% more heat is produced than the input electrical-energy!

The present author later-on while presenting the possibility of nuclear-fusion in arc-welding [3], during ICCF-16, came to know through Dr. M. Srinivasan (Chairman, organizing committee, ICCF-16) that: BARC and Texas A & M University have already reported *possibility of 'nuclear-fusion' in carbon-arc experiments* and have reported [4,5] from mass-spectrographic analysis *possible synthesis of 'Iron' from 'Carbon & Oxygen' in the arc*.

The author & his students too, later-on (in 2011) carried out [6] Under-Water-Arc (UWA) experiments (with the conventional AC-supply) and Carbon-Electrode-Arc (CEA) experiments (with 12 Volt battery driven DC-supply and also with the conventional AC-supply). The rough calorimetric heat-accounting therein [6] indicates marginal excess heat (~ 50%) in the UWA-experiments; and 'surprisingly' much higher excess-heat (~ 700%) in the CEA-experiments, this needs to be re-checked, however .

The possibility of nuclear-fusion (LENR) in arc-plasma indeed seems to be true. Heat-accounting of under-water-arc welding done initially, indicates that marginal excess-heat (~ 50%) is produced. Later, carbon-electrode-arcing experiments conducted yield much higher (~ 700%) excess-heat, and further firmly reinforce the claim for possibility of nuclear-fusion (LENR) in the electric-arc. Spectroscopic-analysis results of other researchers [4,5,7] do support the claim of LENR in the electric-arc. Electric-arc could thus possibly be used for water-heating & steam-generation and hence for power-production with this *simple but revolutionary* proposal of extracting LENR excess-heat of the electric-arc.

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Lattice-induced nuclear excitation and coherent energy exchange in the Karabut experiment

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[2]University of Engineering and Technology, Lahore, Pakistan

More than a decade ago Karabut reported the observation of collimated x-rays in experiments with a high-current glow discharge. At the time, Karabut attributed the effect to x-ray laser emission. From our perspective, the development of a population inversion in the keV regime under the conditions of the experiment is problematic.

We have been interested in coherent energy exchange between a highly-excited vibrational mode and nuclei for many years; such energy transfer would require that the large nuclear quantum be fractionated into a great many oscillator quanta for energy transfer from the nuclei; or massive multi-phonon up-conversion in the case of energy transfer from the oscillator to the nuclei. From the beginning when we first noticed the effect in the lossy spin-boson model more than a decade ago, our models have suggested that such an effect should be possible. In the case of nuclear excitation starting from a highly-excited vibrational mode, we might call the effect lattice-induced nuclear excitation.

The suggestion by one of our colleagues that a lattice-induced nuclear excitation is impossible prompted us to see whether we could design a system based on theory to demonstrate the effect. The design that emerged some years ago involved a sample with many square meters of area driven in the THz regime, which if it worked would produce collimated x-rays from ^{201}Hg near 1.5 keV. At some point we recognized that this is what Karabut's experiment did, and that somehow nature was managing to accomplish the conversion far more effectively than was done in our models. This prompted us to understand whether there might exist some stronger coupling than what we had assumed, which led us to the recognition of a direct coupling between vibrations and internal nuclear degrees of freedom in the relativistic version of the problem. Subsequently we have understood much better why, and under what conditions, these relativistic transitions might be accessible.

Last year we presented results from a model which we thought implemented these ideas. We found that the results seemed to be in agreement with experiment; unfortunately, we understood subsequently that the associated model was broken. At this point, we have developed a new formulation that fixes the errors in last year's version of the model. The issues and modelling are technically involved, and we have submitted abstracts for presentations that focus on the different parts individually.

In this presentation, we present a brief high-level overview of the approach and model, and then discuss results. The results are relevant to the Karabut experiment, and also to a new controlled version of the Karabut experiment that we hope to test later this year.

The two phase diagrams for PdD

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The phase diagram of PdH (and also PdD) has been studied extensively over the past century or more, and is considered to be well understood. However, there is a subtle issue in connection with the phase diagram this is not well understood; this has to do with the stability of the lattice itself, in connection with the different phases.

In the literature, one usually finds the phase diagram for conditions under which the Pd sub-lattice is assumed to be fixed. Given the long relaxation time associated with vacancy diffusion under "normal" conditions, the phase diagram that results is very useful.

However, the addition of H or D causes the vacancies to be stabilized, so at sufficiently high loading the thermodynamic equilibrium favors the vacancy phase. At low or modest temperature this entails no consequence, since in general it is very hard for the vacancy phase to form. However, at higher temperature one would expect the vacancy phase to form, so the vacancy phase will be an important part of the diagram. At lower temperature, the vacancy phase can form through codeposition if the loading is sufficiently high.

It seems useful given this situation to discuss the phase diagram at low temperature under conditions where codeposition can form new lattice, in order to emphasize that the new material can be very different than what lies underneath as a consequence of the phase diagram. In a sense, we really need two phase diagrams to understand PdD.

Relativistic coupling between lattice vibrations and nuclear excitation

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For many years we have been interested in understanding the origin of the coupling between the condensed matter system and nuclei in connection with the anomalies that have been observed in Fleischmann-Pons and related experiments. Over the past two years, it has become clear that collimated x-rays in the Karabut experiment can only be consistent with our coherent energy exchange theory if there exists a very strong coupling between lattice vibrations and nuclear transitions.

We have examined the problem many times in previous years, usually with the conclusion that there can be no such effect in the non-relativistic problem. This is a consequence of the clean separation between the center of mass dynamics and relative dynamics which occurs in non-relativistic models.

This motivated us to study the same issue for relativistic dynamics. In this case the fundamental theory includes a very strong coupling between the center of mass momentum operator, and internal nuclear transitions. This coupling is connected to changes in the internal structure of a composite when it moves (as a result of the Lorentz transform), compared to the rest frame wavefunction. Under normal conditions a generalized Foldy-Wouthuysen transformation eliminates this strong coupling, which results in a model in the rotated frame with no residual first-order interaction. As a result, one would expect generally not expect any significant coupling to survive. The conditions under which any residual coupling would be expected are the same conditions where the generalized Foldy-Wouthuysen rotation "breaks down".

Since the Foldy-Wouthuysen transformation is a simple mathematical operation associated with a change of basis, it can't not work. However, there are certainly examples where it is sufficiently unhelpful that we might think of it as breaking down. One example is in the spin-boson model, where a generalized Foldy-Wouthuysen transformation eliminates the first-order coupling, leaving only a small residual higher-order interaction. In the presence of strong Brillouin-Wigner loss, the model acts very differently, allowing coherent energy exchange under conditions where a large quantum is fractionated. In this case the Foldy-Wouthuysen transformation "breaks down" in that it becomes very difficult to deal with the loss operator in the rotated picture.

Under conditions where the Foldy-Wouthuysen transformation "breaks down" in this sense due to the presence of a strong Brillouin-Wigner loss operator, there exists no useful general non-relativistic limit. In this case, the strong coupling between the center of mass momentum and internal nuclear states remains, and can be used for coherent dynamical processes. In our view, this is the physical origin of the anomalies.

Analysis of compressional mode excitation in an air capacitor configuration for a controlled Karabut experiment

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Karabut has reported the observation of collimated x-rays near 1.5 keV from an experiment done in a high-current glow discharge, which is a result that we consider to be one of the most important in the field of condensed matter nuclear science. We have interpreted this experiment as demonstrating coherent energy transfer between a highly-excited acoustic vibrational mode near 50 MHz and the 1565 eV transition in ^{201}Hg. This nuclear transition is special in that it is the lowest energy transition from the ground state in any stable nucleus.

During the past year we have worked on the design of a controlled version of the Karabut experiment. If our interpretation of the experiment is correct, then what is required to create the collimated x-rays includes strong excitation of the lowest compressional mode of the metal cathode, and deposition of mercury on the cathode surface. Neither of these effects are controlled in Karabut's experiment. We are interested in the development of a new experiment in which we excite a compressional mode that we choose at its resonant frequency, with an excitation level determined by the stimulation that we apply, and with a measurement of the supplied power to the vibrational mode.

We have proposed for this the simplest possible configuration of an air capacitor that is driven at a frequency half of the resonant frequency of the target mode. The coupled electric and mechanical problem that results is sufficiently simple that it is nearly a homework problem in an engineering class, and we are able to develop analytical results throughout for the mechanical displacement as a function of the applied voltage.

In this presentation we will describe the proposed experiment, and describe the proposed air capacitor system in detail. The associated elastic model based on mode solutions of the Naviar equation in cylindrical coordinates will be described, and analytic relations between the mode energy and dissipated power will be given in terms of the drive voltage. We have developed a numerical example in which a disk similar in size and shape to cathodes used by Karabut are driven to a level of excitation that we estimated last year might have been achieved in Karabut's experiment.

This analysis was done in order to support an experimental effort aimed at demonstrating coherent energy exchange between the vibrational mode and surface ^{201}Hg mercury nuclei that we hope to pursue this year.

Born-Oppenheimer and fixed basis models for vibrations in a metal lattice and phonon fluctuations

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Last year we presented results on a model for Karabut's collimated x-rays which seemed to give good agreement with experiment. When writing up the model for publication, we found an error, which forced us to pursue a different version of the model. The issue in the earlier model was that phonon-nuclear coupling based on the relativistic interaction by itself is insufficient to allow for coherent energy exchange between vibrations and nuclear excitation with as much up-conversion as seems to occur in the Karabut experiment. In the new model, we combine phonon-nuclear interactions with electron-phonon interactions to increase the fractionation power of the combined system.

In order to implement the model, we require a description of phonon fluctuations in a metal lattice, formulated in a way so as to be consistent with our phonon-nuclear coupling models. While this might seem to be straightforward, we found that a new formulation of the electron-phonon problem for metals was needed.

At issue is deciding what constitutes phonon exchange. In the literature this problem was attacked in the early years following the development of quantum mechanics making use of phonon exchange in the Bloch picture. In our work, the question arose as to how this relates to the notion of phonon exchange in the Born-Oppenheimer picture, since in this case what seems to be a philosophical difference between the two pictures ends up leading to a difference in how phonon fluctuations are modelled. One can find in the literature a derivation of the Bloch picture model starting from a Born-Oppenheimer picture, so that it is understood how the Bloch picture comes about in the first place starting from a Born-Oppenheimer model.

In a sense, phonon exchange in the Born-Oppenheimer picture is a much weaker effect than in the Bloch picture, so we felt that it was important to understand how the Born-Oppenheimer picture works in the context of phonons in metals. In the new model, the ability of the system to fractionate a large quantum is determined by the level of phonon fluctuations that arise due to dynamical interactions with the electronic degrees of freedom, and this can be readily identified within the Born-Oppenheimer picture. So, we first carried out a general (and formal) Born-Oppenheimer analysis of the problem, which gives very general results (which are easy to understand, but hard to implement to obtain quantitative results). Then we reduced the model in a fixed basis approximation, which results in a model that looks similar to a Bloch picture model, but has a different electron-phonon interaction (one that is well known in the literature). Although to be consistent we should use fixed basis electronic wavefunctions consistent with the Born-Oppenheimer approximation, based on the extensive literature in the Bloch picture it seems clear that one can in some cases extend analyses similar to the Bloch picture to this new model.

In the end we obtain expressions for the phonon dispersion relation that are closely related to the Bloch picture results, but which distinguish between contributions from screening and from phonon exchange; these parts can be understood in terms of the longitudinal dielectric constant. We also obtain expressions for the matrix elements associated with the off-diagonal sector Hamiltonians associated with phonon fluctuations. These latter parameters can then be used to evaluate coherent energy exchange under conditions where a large quantum is fractionated.

Theoretical landscape in condensed matter nuclear science consistent with phonon theory

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Since the initial report of anomalies in PdD by Fleischmann and Pons back in 1989, a variety of anomalies have been seen in experiments of all kinds over the years. Although there is not agreement within our field as to precisely which anomalies should be accepted as real, in our view there is evidence for excess heat production in PdD with associated ^{4}He emission; slow tritium production; light water excess heat in the NiH system; low-level neutron and charged particle emission; weak gamma emission; collimated x-ray emission; and different kinds of transmutation effects. None of these effects are predicted from conventional nuclear or solid state physics.

Over the years we have pursued theories that describe coherent dynamics in nuclear states, in which coherent energy exchange with a highly-excited phonon mode occurs. More than a decade ago a toy mathematical model (the lossy spin-boson model) was found that was capable of demonstrating substantial coherent energy exchange rates under conditions where a large two-level system quantum is fractionated into a very large number of oscillator quanta. Later, we proposed and studied a generalization of the model (which we called the donor and receiver model) which in our view implemented essentially all of the mechanisms that would be needed to account for excess heat in the Fleischmann-Pons experiment.

More recently we have developed a new physics-based version of the model which allow us to extend the theory to describe coherent dynamics in physical systems. The simplest example of one of the new processes in the new theory is energy transfer from a highly-excited vibrational mode to couple to nuclear transitions, leading to nuclear excitation. We interpreted collimated x-ray emission in the Karabut experiment as an example of this mechanism. Gamma emission in the Gozzi experiment, and in Piantelli's experiment, in our view seems consistent with this mechanism.

In our view, the panoply of anomalies in CMNS experiments which our community focuses on must involve a single underlying mechanism, which expresses itself in different ways under different conditions. If we suppose that the phonon-nuclear coupling and coherent dynamics that we have studied is this underlying mechanism, then we might take a step back and see what collection of physical effects we might expect if we take a systematic approach to the associated theory. What results from this exercise might be considered to be a theoretical landscape.

In this presentation we provide an overview of this new theoretical landscape. The simplest class of mechanisms include lattice-induced nuclear excitation generally; subsequent radiative decay can lead to x-ray emission or gamma emission; and subsequent alpha-decay or other disintegration would produce transmutation (which we might consider overall to be a "cold fission" effect). In essence, we might expect to observe energy production under conditions where no hydrogen or deuterium is present (as claimed in experiments at Proton-21). Fusion reactions between two deuterons, or hydrogen and deuterium, combined with coherent energy exchange could account for excess heat, helium, and tritium production. In this case a generalized donor and receiver model seems relevant, and whether the vibrational modes are acoustic or optical impacts which receiver transitions are relevant. The model suggests that ^{3}He should be seen in NiH experiments. A number of reaction pathways within the picture lead to low-level nuclear emission. The most problematic anomaly is transmutation with an associated mass increase (as claimed in the Iwamura experiment), which if real requires a neutron exchange effect combined with coherent energy exchange with the lattice.

Hydrogen Absorption Property of Pd-Doped Porous Materials

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In electrochemical loading of Pd with deuterium, it has been known that attaining a D/Pd value larger than 0.88 is necessary for triggering excess heat effects [1]. It has been reported by Arata and Zhang that the heat arising from D-D nuclear fusion reaction in solid is observed simply by pressurizing nano-Pd/ZrO_2 system with deuterium gas [2]. It seems that nano-scale Pd particles absorb more hydrogen than Pd bulk and use of nano-Pd is advantageous to induce anomalous heat effect in gas loading experiments.

We have reported that the isotope effect for heat generation upon pressurization with hydrogen isotope gases was clearly observed in a reproducible manner for both Pd-doped zeolite with a pore size of ~1.1nm and Pd-doped FSM (Folded Sheet Mesoporous silica [3]) with a pore size of 1.5 ~ 2 nm [4].

In the present study, we have measured hydrogen absorption capacity for Pd-doped zeolite and Pd-doped FSM using the volumetric method. The results are compared with those of non-doped materials. The measurements were conducted repeatedly in order to separate the apparent capacity arising from the reducing reaction of oxidized Pd.

The results of hydrogen absorption capacity of Pd-doped porous materials will be discussed based on the contribution from the hydrogen adsorption capacity of the matrices.

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Model of Two-Picometer Deuteron Clusters for LENR Supported by Laser Emission of Nuclear Reactions Products

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Results about nuclear reactions of deuterons in 2 pm distance was specified [1] in support of the experiments [2] for LENR based on an evaluation of results of Prelas et al. were a Coulomb screening by a factor 13 was derived [3]. These results were especially fitting the later results of ultrahigh density clusters fulfilling conditions of Bose-Einstein condensation [4] where the conditions of surface states with swimming electron layers appeared to be of advantage. These results are now supported by recent measurement [5] of emission of nuclear reaction products from the states of clusters within the voids in crystals (Schottky defects). An evaluation of these developments is presented for comparison about ongoing experimental results of LENR with the measurements of large amounts of neutrons [2] from nuclear reactions in the LENR sources. These results are supported by the detailed quantum mechanical evaluation of the Coulomb screening computations which arrived at the same values as the phenomenological evaluations of the measurements of Prelas et al. [3].

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Live Open Science, a Good fit for LENR Research

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Abstract:

Inspired by the historical evolution of research in LENR, the Martin Fleischmann Memorial Project is inventing a new way to investigate the phenomenon, the so called "live Open Science" (LOS) approach. This paper presents the methodology and the tools that are necessary to harness the power of the crowd in the pursuit of science, filling the gap between labs and journals, and speeding up the experimental review and consequent iterative process. The implications of this "new way of doing science", when done well, are enhanced credibility through rapid peer review, and rapid dissemination of new knowledge. The ability of the approach to identify problems and poor approaches early is highlighted.

LOS is the logical extension of public knowledge diffusion that was implemented by creative common licensing and the open source software revolution but applied to the oldest form of cartesian process. The paper describes the game changing nature of internet enabled distributed funding and research. Collaboration tools and methodologies are explored.

The power of data aggregation and live publishing to the web with real time graphing capability even on mobile platforms is discussed. The ability of the crowd to download, analyse and critique historical and live 24/7 raw data without a tendency to group think or goal seek, because of a lack of vested interest, is explored. The benefits and challenges of an open approach to experiment and protocol design are elaborated upon.

The ability of online project management and tracking, multi-way video calling, live open documents with many simultaneous authors, regular progress update blogging and video production to accelerate scientific exploration is discussed in depth.

The lack of funding that LENR research has traditionally suffered and the distributed nature of the researchers lends itself particularly well to the LOS approach.

The current basis for disruptive technology is exemplified by ARM Holdings CPU designs and Google Android OS. One is hardware the other software but in both cases the core technology is developed and, even if proprietary, is then made available for others to build their systems around, extending and amending as needed to fit a particular requirement. This distributed development process retains key stakeholder IP and is similar to the way our project is organised. Like the mobile industry, parallels are highlighted that indicate that LOS can promote the adoption, extension and application of LENR technology.

Electrochemical-Physical Activation of Nickel-Cathode Surfaces

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Experimental evidence for low energy nuclear reactions (LENR) is based mostly on measurements of excess amounts of thermal energy that are generated during the electrolysis of heavy water using palladium cathodes. These excess thermal energy events, however, cannot be explained by established electrochemical energy balance considerations. This experimental investigation focusses on finding root-causes for such thermal events rather than measuring the events. In order to gain insight of macroscopic physical electrode behavior, cathodes of nickel in light water electrolytes are used as practical models for metal-hydrogen systems to investigate the mechanics of gas evolution. The surface microstructure of electroplated nickel cathodes was the initial object for the investigation of hydrogen gas bubble formation. During these studies a surprising physical cathode-surface-effect was observed at the onset of gas evolution periods. The observation of this effect has not been found -and reported on- in the scientific literature for the nickel-hydrogen binary system, even though this system has been investigated intensely for nearly a century. The readily produced physical effect, observed at the surface of nickel cathodes, leads to the conclusion that during hydrogen gas evolution metastable surface-lattice conditions are created, which lead to, and explain, the initiation of surface phonons that are part of possible causes for LENR thermal events.

In the description of the experimental investigation, cell configurations, electrolytes, preparation methods, cathode surface structures, and physical behavior of cathode surfaces are given. The methods for producing the electrochemical-physical cathode activation effect, detailed observation of the effect, and its potential relationship with other metal-hydrogen systems, are described. Also, an attempt is made to interpret the results of this model-study in order to obtain an understanding of the reasons for poor reproducibility of LENR-thermal events by independent investigators, as well as, explaining thermal event observations (by others) such as "after death" excess heat generation on palladium-deuterium cathodes.

Recent Advances in Deuterium Permeation Induced Transmutation Experiments using Nano-Structured Pd/CaO/Pd Multilayer Thin Film

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Permeation induced transmutation reactions, which we originally found in the nano-structured Pd multilayer film composed of Pd and CaO thin film and Pd substrate [1], have been observed in our laboratory and other research institutes[2]-[4]. Recently, Toyota R&D centre reported almost complete replication experiments on the transmutation of Cs into Pr at ICCF-17[2]. We observed transmutation reactions of Cs into Pr, Ba into Sm, W into Pt up to now. Especially, transmutation of Cs into Pr has been confirmed by "in-situ" measurements using x-ray fluorescence spectrometry (XRF) at SPring-8 in Japan [5].

Experimental data that indicates the presence of transmutation have been accumulated and the underlying mechanism for inducing low energy transmutation reactions is gradually becoming clear, although systematic experimental study is still insufficient. The permeation induced transmutation technology would be expected as an innovative nuclear transmutation method for radioactive waste and a new energy source if we would be able to increase the amount of transmutation products.

We have been trying to increase the amount of transmutation products these years for the practical application. The following factors are assumed to be important for inducing deuterium permeation transmutation.

1) Local Deuteron Density
2) Electronic Structure

Based on this assumption, we applied an electrochemical method to increase the local deuteron density near the surface of the nano-structured Pd multilayer film. We also tried to increase the transmutation products by changing surface electronic state. These recent experimental methods gave us increased transmutation products, gamma-ray emissions, and new implications on Deuterium Permeation Induced Transmutation.

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Empirical Evidence for Two Distinct Effects: Low-level d-d Fusion in Metals and Anomalous Excess Heat

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There are at least two distinct phenomena present in so-called cold-fusion experiments. First, there is a confirmed effect showing energetic products of d-d fusion (e.g., neutrons and tritons) in metals at low levels. This is true 'cold fusion' with some metals enhancing the d-d-fusion rate better than others. This small nuclear effect is now fully repeatable, when the metals are properly prepared. I will discuss early and confirming published data.

Second, there is an excess heat effect observed in some experiments, properly called 'anomalous excess heat' since we do not know with certainty where the energy originates. I consider the anomalous heat to be real but a separate phenomenon from the small enhanced-fusion effect in metals.

To be certain that the anomalous excess heat effect is nuclear in origin requires finding nuclear products that arise at the same *time* and in the same *quantities* to correlate with the excess heat observed. Otherwise, one cannot definitively say that the anomalous heat is nuclear in origin. I allow that there may be other forms of energy in the universe that we earthlings have yet to ferret out.

In an effort to consistently achieve anomalous heat (energy) whether or not it is nuclear in origin, I and other energy researchers are pursuing several non-conventional approaches. Here I will emphasize anomalous heat experiments involving ordinary light water, the measurement methods I use, and results.

New measurement of screening potential by ‘cooperative colliding process’ for the d+d reaction in metallic electron environment

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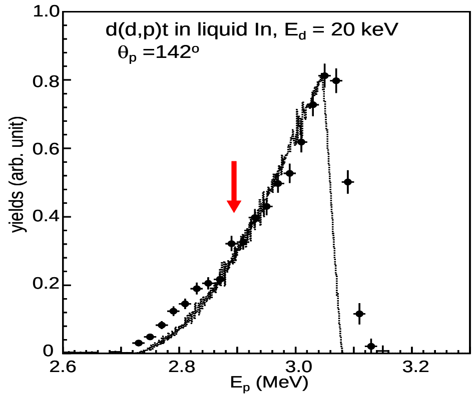
Screening for nuclear reactions in metal plays an important role to understand the mechanism of the cold fusion. Although large values of the screening potential were reported in deuteron beam experiments for various metals, the experiments so far performed are not faultless but possibly bring large systematic errors due to uncertainties of target deuteron density. Having performed a series of low-energy deuteron beam experiments to explore enhanced nuclear reactions in various environments, we found a new reaction process which ensures to determine the screening potential much more accurately. The process is unique to the molecular beam and was found as a strange d+d reaction induced by D_3^+ molecular beams in liquid Indium: we call it ‘cooperative colliding d+d reaction’.

Experimental setups were almost same as reported in [1]. Solid and liquid In were bombarded by D_3^+ beams from 15 to 60 keV (E_d = 5~20 keV). For the liquid, the metal In was liquefied by heating up above the melting point (156.6°C). Protons and tritons from the d(d,p)t reaction were measured by a Si detector with the energy resolution of about 20 keV.

The following results are characteristics of the cooperative colliding d+d reaction observed in liquid In: ①Energy spectra are quite odd. Such an example of proton spectra is shown in Fig. 1 with solid circles. The shape is very broad and is largely skewed. Moreover, the peak position shifts to higher energy than that of the normal spectrum (shown by an arrow). ②An excitation function of the yield cannot be explained by the thick target yield of the d(d,p)t reaction. The yield for the liquid In decreases much slower with decrease of incident energy than the normal thick target yield. ③ When bombarded by an atomic D^+ beam, the yield of the d+d reaction diminishes, at least less than 1/70 of that by the D_3^+ beam.

In the cooperative colliding reaction, two deuterons in a molecule play an essential role as shown schematically in Fig. 2: one deuteron in a molecule is elastically scattered by In, and, then, it collides with the other to cause the d(d,p)t reaction. Since the reaction occurs with the partner in the molecule, a trajectory (the initial position and the collision point) is inevitably determined. The solid curve in Fig. 1 is a proton spectrum calculated by the cooperative colliding mechanism with simple assumptions for the D_3 molecule. The calculation reproduces well not only the energy spectra, but also the excitation function. Detailed analyses will bring accurate information on the screening potential between deuterons surrounded by conduction electrons.



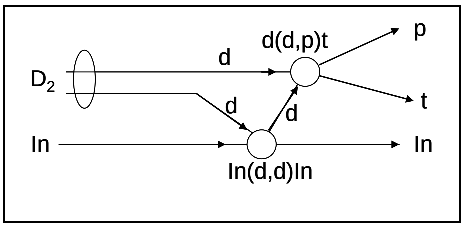


Figure 2: *Cooperative colliding reaction.*

Figure 1: *Proton spectrum measured at θ = 142°.*
An arrow shows the peak position of protons emitted from the normal d(d,p)t reaction.

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Biography

David A. Kidwell, Ph.D.

Dr. Kidwell received his B.S. in chemistry from the University of North Carolina at Greensboro in 1978, *Magna cum laude*. He received his Ph.D. in 1982 from the Massachusetts Institute of Technology in organic chemistry applying mass spectrometry, NMR, and HPLC to the structural analysis of organic biomolecules. At MIT, for relaxation, he took up assembly language programming on an Apple IIe and wrote several commercial programs as well as designed interfaces to attach other hardware. This cemented his life-long interest in electronics and programming. After MIT, he received an NRC-NRL Post Doctoral Associateship at the Naval Research Laboratory (NRL) in the area of Secondary Ion Mass Spectrometry, applying this technology to the detection of drugs of abuse.

For the initial part of his career at NRL, he worked at developing better screening tests, better immunoassays, and novel mass spectrometric confirmation tests for drugs of abuse in the diverse matrices of saliva, urine, hair, and sweat. Dr. Kidwell was one of the first to propose new mechanisms by which drugs of abuse bind to hair, observe bias in hair testing, and point out the inadequacies of decontamination procedures to remove inadvertent environmental contamination. He is a court certified expert on hair testing for drugs of abuse, a field in which he is well known. He is also known for his work on determining drug use by sweat testing, where like in hair analysis, environmental contamination can play a role in generating false positives.

As a member of the Surface Nanoscience and Sensor Technology Section of the Surface Chemistry Branch, Dr. Kidwell developed small, multi-diverse sensor packages for deployment in the environment and field use. More recently, continuing with the theme of trace analysis in diverse matrices, he developed an ICP-MS technique for detection of Pr in Pd at the PPQ levels and tested the theory of transmutation of Cs into Pr by LENR. He has constructed a number of instruments and software packages for the study of heat production in LENR experiments and applied them to the study of gas loading. With precision calorimetry, he found unusual results in gas loading using sub-nanometer palladium particles in zeolites or alumina supports where some of the energy evolved during gas loading could not be explained by conventional chemistry.

He has published over 80 technical papers and book chapters, made over 100 presentations on his work, and holds seventeen patents.

Low Energy Nuclear Reaction Research at the Naval Research Laboratory

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We have explored the field of Low Energy Nuclear Reactions (LENR) for about eight years focusing on transmutation, electrochemistry, and gas loading with the latter two being the most fruitful. In electrochemistry, palladium foil is loaded with deuterium in a closed electrochemical cell contained in a calorimeter. Occasionally, excess energy is produced that is much larger than can be accounted for by chemistry or the electrical input into the system. Unfortunately, the poor reproducibility (<6%) prevented discovery of the trigger for this excess heat. In gas loading, palladium nanoparticles are pressurized with deuterium. While the resultant heat is very reproducible, it is much lower than from electrochemical experiments and therefore harder to characterize as unconventional chemistry. In both approaches to LENR only energy (as heat) is produced – neither nuclear products nor transmutations have been firmly established.

Science is data driven. Once a hypothesis is formed, the most important scientific task is to disprove the hypothesis. Only after failure to find conflicting data is a hypothesis accepted as likely correct, but that acceptance can change on a moments notice when new data arises. Although simple in concept, LENR experiments have subtle pitfalls to trap the more casual researcher, and much of our effort has gone into uncovering these pitfalls. Through a historical perspective, I will discuss the application of the scientific method to selected results and how incorrect conclusions could have been easily made. In contrast, we can find no artifacts to explain the data for some of our results, and therefore we must conclude that an unknown source of energy exists and is worthy of more attention.

Theoretical Analysis and Reaction Mechanisms for Experimental Results of Hydrogen-Nickel Systems

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Theoretical analysis and reaction mechanisms will be presented for anomalous heat effect (AHE) observed for hydrogen-Nickel systems [1], using a generalized conventional theory [2-14] which are based on the optical theorem formulation of low-energy nuclear reactions (OTF-LENRs) [2] and also based on generalization [3] of the theory of Bose-Einstein condensation nuclear fusion (BECNF) in micro/nano-scale metal particles [4-15].

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http://www.physics.purdue.edu/people/faculty/yekim.shtml

A Mass-Flow-Calorimetry System for Scaled-up Experiments on Anomalous Heat Evolution at Elevated Temperatures

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We have been studying phenomena of anomalous heat evolution from hydrogen-isotope-loaded nano-composite samples at elevated temperatures as well as at room temperature using a twin absorption system [1, 2]. Recent experiments have used Ni-based nano-composite samples; Pd_1Ni_7/ZrO_2 ("PNZ"), Ni/ZrO_2 ("NZ"), $Cu_{0.081}Ni_{0.36}/ZrO_2$ ("CNZ") and $Cu_{0.21}Ni_{0.21}/ZrO_2$ ("CNZII"). The results of measurements have been presented in the meetings of the 12th Japan CF-Research Society (JCF12), the 17th International Conference on Condensed Matter Nuclear Science (ICCF17) and the 13th Japan CF-Research Society (JCF13), and have been/will be published in [3], [4] and [5], respectively.

These will be summarized, and the time-dependent data will be re-analyzed in another paper by A. Takahashi in this Conference for speculating heat releasing mechanisms during the several-week-lasted phase of D(H)-loading into the nano-composite samples. As will be shown there, a lot of interesting, even astonishing, features are involved; burst-like heat release with anomalously high values of differential heat of sorption (η) reaching ca. 600 eV/atom-H, large values of integrated heat reaching ca. 800 eV/atom-Ni from the CNZ sample absorbing H, and abrupt desorption with absorbed energy of 50 - 80 eV/atom-Ni observed almost exclusively in the first 573-K run for each sample.

To confirm the interesting phenomena, repeated measurements with improved signal-to-noise ratio are required. Since the easiest way for this is to increase the sample amount, we have fabricated a reaction chamber with a ten-times-larger volume than in-being one. Another important improvement is a mass flow calorimetry applied to the system using an oil coolant with a boiling point of 390 deg-C. Moreover, to make residual gas mass spectral analysis in A = 1 - 6 amu range, a QMA system is going to be installed in the line of the apparatus.

In the presentation we will show the schematics of this new oil-cooling mass-flow calorimetry system for observing anomalous heat evolution in H(D)-gas charging to Ni-based nano-composite samples and for calibration runs using blank alumina sample.

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Applying the Scientific Method to Understand Anomalous Heat Effect

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Scientific methods in nuclear science are proposed to understand anomalous heat effect: (1) Neutrino Detection; (2) Internal Conversion Electrons; (3) RF emission and magnetic field fluctuation; (4) 3-Deuteron reaction; (5) Solid State Nuclear Track Detector(CR-39); (6) ^{6}Li+p resonance at low energy.

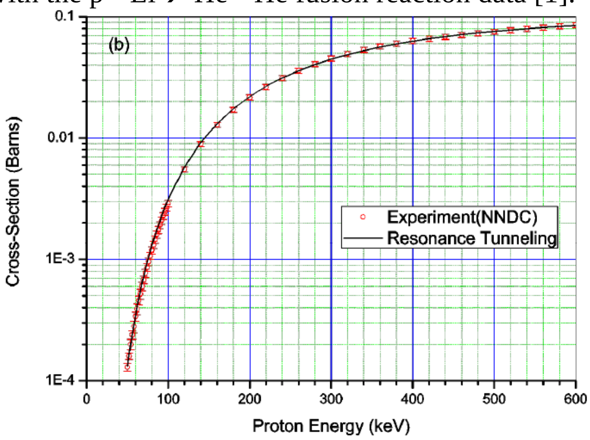
NEUTRINO Resonant tunnelling has been proposed to solve the 3 puzzles of Huizenga: i.e. penetration of Coulomb barrier, incommensurable neutron and gamma emission with excess heat. The weak interaction is proposed to compete with the strong nuclear interaction and the electromagnetic interaction. In other words, weak interaction is picked-up for matching the Coulomb barrier in terms of the selectivity of resonance. Then, the necessary nuclear product is neutrino. It was thought impossible to detect neutrino emission in order to confirm this weak interaction. The recent progress in neutrino detection will be reported, and the requirements for a preliminary experiment would be discussed

INTERNAL CONVERSION ELECTRONS If anomalous heat effect is caused by nuclear energy, it must be transferred from nuclei to the surrounding electrons eventually. A possible mechanism is the internal conversion electron which is supposed to win over the high energy gamma emission. High nuclear spin and dense energy levels are necessary conditions for the internal conversion electrons to win over the gamma emission. The Defkalion's **RF emission and the strong magnetic field** fluctuation after the excitation of high spin Rydberg state were the possible hint in this direction. A calculation of internal conversion coefficient for the case of resonant tunnelling in metal-hydrides (deuterides) is desirable.

3-DEUTERON REACTION A long-lifetime resonance state is supposed to be formed as a result of the selective resonant tunnelling. It might be detectable using an incoming beam to interact with such a long-lifetime state. The 3-deuteron reaction products might be an evidence of this d+d resonant tunnelling.

SOLID STATE NUCLEAR TRACK DETECTOR(CR-39) Linear Energy Transfer (LET) is applied to analyze the CR-39 data to show clearly the reproducibility of the co-deposition experiments initiated at SPAWAR.

LITHIUM-6 + PROTON FUSION REACTION DATA Selective resonant tunnelling has been proved to be consistent with the p+^{6}Li→^{4}He+^{3}He fusion reaction data [1].



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Porous Palladium Substrates by Cosputtering and Dealloying to Enhance Hydrogen/Deuterium Loading

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Anomalous heat generation in palladium-based materials in the presence of deuterium has been a subject of active research since Martin Fleischmann and Stanley Pons claimed this mysterious phenomenon as nuclear fusion. More recently, nanostructured palladium have been investigated due to the large surface area that would increase the deuterium loading. We have developed a process to obtain nanoporous palladium foil by cosputtering and dealloying technique. Nickel-Palladium alloy (NiPd) films were cosputtered on plain palladium foil as well as on aqua regia etched palladium foil by sputtering system. Dealloying, is a technique where an element is selectively etched out from an alloy. Ferric chloride was used to etch Nickel from NiPd films. As deposited and dealloyed films were characterized by different analytical tools like X-ray diffractometer, EDX, electrochemical measurements and SEM. Elemental analysis confirm that Nickel is completely removed after dealloying and SEM images reveal a Micro/nano porous palladium structure. Cyclic Voltammetry (CV) measurements show high electrochemically active surface area implying the fabricated porous structure grants easy access to the electrolyte solution. Studies are underway to determine the effect of porosity on the loading of hydrogen/deuterium in these porous palladium structures.

Water-Free Replication of Pons-Fleischmann LENR

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Excess heat has been produced by a method conceptually similar to that of Pons and Fleischmann[1] except that it does not involve electrolysis or even water (heavy or light). Instead of putting hydrogen into the system by operation for a few days, the hydrogen solute is quenched into the electrode alloy, by temperature and pressure, before the cell is assembled.

The cell contains two hydrogenated alloy electrodes separated by an insulating textile layer. Substituting for the Pons-Fleischmann (P-F) electrolyte, an oil based conductor containing very fine particles of an electrically conducting solid is soaked into the separator textile. Thus, the cell is a low Q capacitor, with the nuclear active environment[2] initially installed.

I believe that a basis for the P-F effect is a critical distribution of electric current across the surface of the cathode, both spatially and temporally, that is regulated by the moving layer of electrolytic hydrogen bubbles on that surface. Erratic behaviour of those bubbles accounts for the inconsistency typically observed in P-F experiments. In my work, the fine particles in the conductor create near-point-sources of current that (with brownian motion) create the charge distribution that seems necessary to trigger the nuclear reaction producing P-F excess heat.

Typically, the low Q capacitor method has yielded about 15% more thermal energy than electric power input. Excess heat increases disporportionally with increasing electrical current. The system seems far from optimized, however.

With the oil-based conductor, excess heat appears almost immediately, and much more consistently, compared to the classic P-F method. There are also more, and more-controllable, variables for optimization of the effect.

This presentation will report experiments using a well-controlled, evacuated, seebeck-type calorimeter using direct current activation. Total power is typically a few hundred milliwatts; electrode mass is one to two grams. Most experiments have been with copper based alloys; nickel is under way. Results with and without light hydrogen solute are shown. Use of additional alloying ingredients (especially boron) is described.

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Composite model for LENR in linear defects of a lattice

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Mathematical models for Low-Energy Nuclear Fusion (LENR) of hydrogen, H, and deuterium, D, are brought together in the context of over 20 years of searching for the answer to the source of nuclear fusion without the requisite kinetic energy to overcome a nuclear Coulomb barrier. The earliest of these models is Julian Schwinger's proposal [1] to combine, in a single Hamiltonian, the attractive nuclear potential with the repulsive Coulomb potential to reach an excited state of ^{4}He. The second was K.P. Sinha's 1999 model [2] to use the natural electron pairing to form charge-polarized D^+ D^- pairs in a linear defect that is attractive rather than repulsive. Ed Storms' linear array of hydrogen 'atoms' in a gap or crevice in the lattice appears to combine Schwinger's and Sinha's concepts. Portions of other models, where applicable, are mentioned.

Another paper, to be presented in this conference, will provide a pictorial description of phonon activity in Sinha's linear array (and presumably Storms' also) of D or H atoms. The present paper concentrates first on a description of the many parameters and conditions necessary to solve the problem. (It will neither present nor solve the full equations.) The full Hamiltonian for the process must cover distances from the lattice spacing down to the nuclear force region. The different forces and frequencies involved in the various component interactions of the system vary greatly over this range of five orders of magnitude. The critical processes are mentioned along with their interdependencies. The importance of each model's contributions is highlighted. An appendix on mathematical modeling of the system provides more details and integration of the equations involved.

This model does not address all aspects of the LENR process, but it does lead to some of the mechanisms that can explain observed data. These include: a means of overcoming the nuclear coulomb barrier by linearizing and overlapping multiple bound atomic-electron trajectories along with the hydrogen sub-lattice; a means of dissipating nuclear energy to the lattice gradually, but before the protons actually are bound by their mutual nuclear forces; and a means of fusing deuterons into ^{4}He without ever occupying the excited states that fragment into the known 'hot' fusion products of protons, neutrons, tritium, and 3He, or energetic gamma rays. It also provides a means of forming hydrogen femto-molecules (H_2(f), or perhaps even H_n(f)), as an alternative path for the p-e-p or p-e-e-p fusion to deuterium.

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Decay of $^4He^{*\wedge}$ from PdD and transmutation

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Present Lochon and Extended-Lochon Models for the low-energy nuclear reaction, LENR, fusion process predict the fusion of monatomic deuterium into a sub-fragmentation level excited condition of $^4He^{*\wedge}$. The **^** and * indicate the presence of deep-Dirac level (DDL) electrons and of an excited nuclear state respectively.[i] The higher angular-momentum deuterium combinations result in the formation of femto-deuterium molecules or molecular ions, $D_2^{\wedge}$ or $D_2^{+\wedge}$. Both the $^4He^{*\wedge}$ and femto-deuterium molecules are expected to be short lived (<1fs). However, the short life may be determined more by their fusion with other nuclei than with their decay time to ^4He.

The $^4He^{*\wedge}$ and femto molecules and ions would be highly mobile in the lattice because of their multi-femtometer size. However, because of the Coulomb barrier, the positively charged ion, $D_2^{+\wedge}$ or $^4He^{*+\wedge}$, would not penetrate a nucleus as would the neutral 4He*^ and femto molecule. The positively charged ion would penetrate an atom's electron cloud, but would interact with atoms as would a proton and form a short-lived 'ordinary' molecule, not a femto molecule.

The LENR fusion process for a $^4He^{*\wedge}$ or $D_2^{\wedge}$ femto-atom or -molecule, with an atomic nucleus of mass A and charge Z could yield transmutation products ranging from (A, Z-2), by weak-nuclear interaction from (A, Z) absorbing one or two electrons to change protons to neutrons, to (A+4, Z-2), absorbing the whole $^4He^{*\wedge}$ femto-atom. It can also form femto-deuterides, with $D_2^{\wedge}$, or a femto-molecule, with $^4He^{*\wedge}$. As in the case for $^1H^{\wedge}$ or $^1H_2^{\wedge}$ femto-atoms or -molecules generated in NiH cold fusion,[ii] the large number of combinations possible is reduced by the stability 'needs' of the particular atomic nucleus with which the femto-atom/molecule fuses. There is sufficient energy in the process for the conversion of the DDL electron(s) and femto-atom or target-nucleus protons to form neutrons. There are sufficient 'building blocks' with which to 'construct' a stable nucleus from the fusion of almost any nucleus with $^4He^{*\wedge}$ or $D_2^{\wedge}$.
Because of the multi-body interaction, strong near-field radiation from tightly bound electrons, and low input energies, energetic particle emission from fusion with these femto-particles is much less common than for normal fusion or neutron-activation processes. The attraction of femto-atoms or -molecules to radioisotopes[iii] will reduce any radioactivity generated by transmutation of lattice nuclei and fusion with any natural, induced, or added, impurities.

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Pictorial description for LENR in linear defects of a lattice

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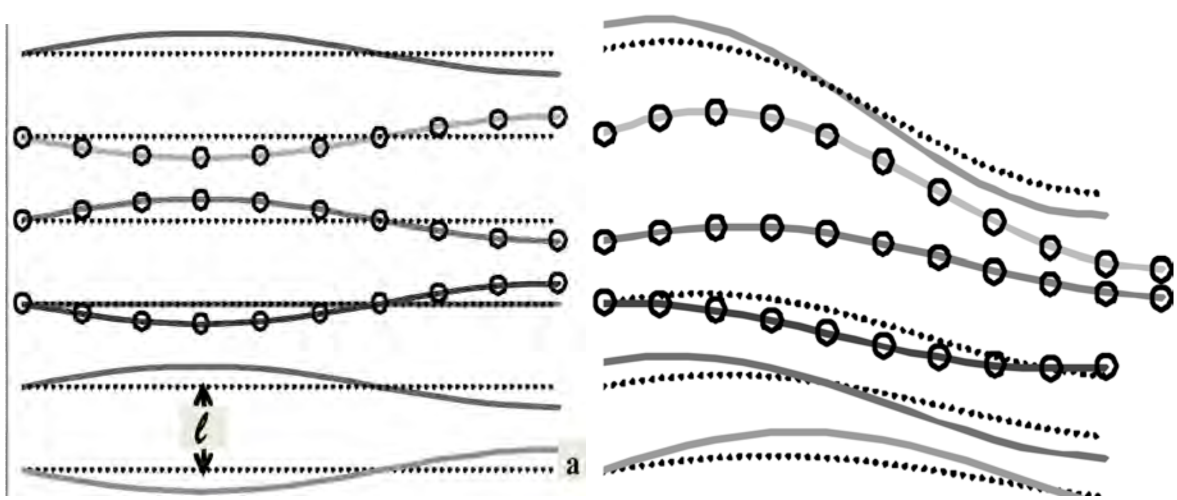
ABSTRACT

The concept of phonons in solid-state physics is based on oscillations of atoms about equilibrium positions within a lattice. These equilibrium positions are usually a fixed distance apart within the lattice and the oscillations are generally a small fraction of that spacing. Under these conditions, the atoms never get closer to one another than $\ell - 2a$, where ℓ is the lattice spacing and 'a' is the maximum amplitude of the atomic oscillation. A model for LENR within crevices of a lattice provides a different scenario. This presentation represents the concepts of, the requirements for, and the implications of, the new picture.

The new concept is that the lattice does not tightly bind the sub-lattice within the linear defect. Under certain conditions, the sub-lattice spacing can become independent of the lattice spacing and sections of the sub-lattice will act like an 'accordion' or a 'Slinky'. The group oscillations, represented by different phonon modes, allow ℓ to change. The figures below indicate the importance of this concept. The leftside figure is the conventional longitudinal optical phonon mode with alternating hydrogen atoms coming together within their individual lattice sites. The lattice barrier limits them before they ever encounter the nuclear Coulomb barrier. The dotted lines indicate the equilibrium values of the lattice (ℓ is fixed) that the hydrogen oscillates about. The rightside figure indicates the additional freedom available to a linear array (sub-lattice) that is not confined by the lattice. The sub-lattice spacing is not defined by the lattice barriers (ℓ is <u>not</u> fixed), but the electron and hydrogen motions may still be limited to one or two dimensions by the lattice. Fluctuations of the sub-lattice spacing, added to that of the phonon modes, greatly reduce the minimum distance possible between hydrogen atoms on a cyclic basis. (Notice the near overlap of the circles that represent the hydrogen atomic orbital dimensions that are significantly less than the lattice spacings.) Other implications of several aspects of CF modelling will be described in this same manner to clarify concepts that, when expressed in equations only, are less easily appreciated by experimentalists in the community.



Time => Time =>

Oscillations of a linear sub-lattice (vertical orientation) over time.

Deep-orbit-electron radiation absorption and emission

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The deep-Dirac level (DDL) electron orbits have been proposed, and rejected, for over 50 years. The rejections have been based on mathematical considerations resulting from the singular Coulomb potential used in the Dirac equations and on lack of observation of such levels. Nevertheless, these orbits explain many things experimentally observed in CF [1] and may be a unique explanation for the low-radiation or nearly radiation-free transmutation measured in both PdD and NiH CF systems [2], It is important to develop the characteristics of these very deep-orbit, relativistic, electrons and their formation of femto-atoms and molecules in more detail.

Important DDL-electron characteristics include:

1. relativistic velocities (>1 MeV) and extremely high EM-radiation fields
2. high binding energy (up to 507 keV)
3. close proximity (within Fermis) to radiating protons in d^ or 4He^ (near-field EM coupling)
4. charge neutralization of protons, deuterons, and helium nuclei is source of transmutation [3]
5. near frequency matching of excited DDL electrons with many-MeV nuclear protons (allows primary pathway for de-excitation of D-D => 4He*^ nuclei)
6. deep, bi-modal, potential well permits DDL electron interaction with both photons and neutrinos and direct resonant energy transfer from nuclear protons (non-photonic coupling)
7. ability to interact with EM fields of nuclear protons within several lattice spacings
8. interaction with protons of radioactive nuclei provides attractive force between femto-atoms or -molecules and radio-isotopes (provides basis for reducing radioactivity in lattice)
9. non-photonic (strong, longitudinal, EM field) coupling to atomic and lattice electrons (strong EM field permits single-pulse energy transfer via non-linear interactions with atom electrons)
10. DDL electrons about radio-nuclides provide ready decay paths and permit radiative discharge of nuclear energy rather than normal energetic-particle/gamma-production pathways

The process of energy transfer involves the near-field electromagnetic coupling of energy of energetic charged nuclear dipoles to tightly co-confined electron dipoles (DDL orbits). From there, the energetic electrons can near-field-couple energy into the adjacent Pd-bound electrons causing intense local ionization, but no energetic radiation beyond the keV x-ray level. The steady loss of nucleon energy to the DDL electron(s) and their disturbing presence in the nuclear region prevent the semi-stable nuclear orbits required for the formation of gamma rays. This paper seeks to qualify the decay processes and identify the conditions and limits required to permit stable and efficient conversion from nuclear energy to thermal energy in the lattice. In particular, it will describe the near-field EM coupling that will take place within the nuclear region. While nuclear-dipole coupling has been studied, the EM coupling of nucleons to tightly bound electrons and thence to nearby bound electrons may be new.

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Distributed Power Source Using Low Energy Nuclear Reactions

#George H. Miley[1,2], Kyu-Jung Kim[1], Tapan Patel[1], Erik Ziehm[1], Bert Stunkard[1], Kathleen Weichman[1], Anaïs Osouf[1], Kyung-Shin Lee[1]
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This project is focused on development of a revolutionary new distributed nuclear power unit using Low Energy Nuclear Reactions (LENRs). This will allow small power units that represent a vital new power supply for both home and light industry power. Due to the low energy of reactants, the compound nucleus formed in LENR has little excess energy, thus the resulting breakout products are mainly channeled into stable or near-stable products, avoiding significant radioactivity or nuclear waste problems. Such a power source enables a tremendous advantage in energy density, lifetime, and tolerance to wide differences in environmental conditions (temperature, pressure). Compared to other renewable power units, LENR units offer significant technical and economic advantages.

During the past decade, extensive experimental and theoretical work has been done worldwide to study the LENR phenomena and to understand its underlying physics. At ICCF-17 several companies announced progress on gas loaded nickel nano-particle units designed for MW size plants. Others, including LENUCO LLC., are working on development of small 10's of kW units. Physically these power units are very simple. Special Ni alloy nano-particle is placed in a pressure vessel which is then pressurized to 60-100 psi with hydrogen to initiate the reaction. With pressure control, these units are expected to run for several years, before replacement of the nano-particles is required due to build up of transmutation products. Replacement is simply done by substitution of a new cylinder containing fresh particles while the used particles are recycled for use in fresh nano-particles. Our results in terms of energy gain from the pressurized nano-particles are among the best reported to date [1, 2]. The main obstacle to development of a practical unit is preventing the hot nanoparticles from overheating and agglomerating together, limiting unit run time [3]. Thus present work is focused on overcoming that problem as well as further development of the technology needed for a practical power unit.

A gas loading system has been devised using a nickel based alloy nano-particle that provides a large output of heat when pressurized to 60~100 psi with hydrogen (alternately deuterium gas using a Pd rich version of the nano-particle alloy can be used).The discovery at the University of Illinois of the existence of Ultra-High-Density clusters inside the host material is a break-through development [1]. Both experimental and theoretical studies have demonstrated that the hydrogen atoms in these clusters (almost metallic hydrogen) are close enough together that diffusion of another atom into the cluster transfers sufficient momentum to create a nuclear transmutation reaction with the hydrogen and host nickel atoms. Incorporating these clusters into the material has resulted in excess heat experiments that reproducibly producing orders of magnitude more heat energy out than energy in. However, as noted earlier, run times are currently limited to hours by the onset of nano-particle agglomeration.

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[3] Anaïs Osouf, et al., "Composition measurements and Imagery of Nanoparticle gas loading experiments as an investigation of LENR reactions**",** submitted, this conference.

Production and Destruction of Elements by Low Energy Nuclear Reactions

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Interest in low energy nuclear reactions (LENR) has two bases. There are (1) compelling scientific reasons for understanding such reactions, and (2) attractive application possibilities for development of systems to produce LENR controllably and reliably. The primary application is the production of power and energy. However, there has long been interest in using LENR to produce transmutation products, that is, to change one element into another [1]. That interest has two facets, the production of valuable elements and the destruction of dangerous isotopes. This paper addresses the potential rates and the practicality of both of these potential applications of LENR.

Some elements are valuable for either or both of two reasons, their rarity and their use for production of high-technology materials and devices. For example, gold, platinum and silver are expensive because they are essentially substitutes for money, and because of their many uses. Rare earths are not currency surrogates, but are needed in many modern products. Currently, the availability of valuable and needed elements depends on the vagaries of geology, as well as political circumstances. It would be useful to be able to produce important elements commercially by LENR transmutations, so there is early commercial interest in doing so. We computed the potential rates for production of elements using LENR under the assumption that the reactions occur on surfaces [2]. Using experimental LENR transmutations rates [3], it was found that only a small fraction of a gram of a desired element would be produced during one year of operation of an LENR reactor. Using theoretical reaction rates and very optimistic reactor assumptions, we compute that one mole of a new element could be produced in about one day [4]. However, such production rates would require processes that would bring reactants to LENR active surfaces, and remove reaction products, both at the required rate and in a manner that would not destroy the efficacy of the active surfaces. Commercial production of valuable elements using LENR does not seem to be economically viable.

For most of the history of research on LENR, there has been interest in the possibility of treating highly radioactive elements from fission reactor waste to render them less dangerous, while simultaneously extracting additional energy from the spent fuels [5]. Hence, we addressed the possibilities for such processing. Simple calculations indicate that, to keep up with the on-going fission waste production, one mole of radioactive materials would have to be handled and successfully subjected to LENR approximately each second. It would require over 10,000 LENR reactors working effectively all of the time to avoid adding to the current massive inventory of radioactive waste. Each reactor would have to have 100 m^2 of continuously effective surface area. The handling of radioactive feed stocks to and from LENR reactors, the activation of such reactors, and handling of heat produced would require massive and costly industrial facilities. Worse, there is no scientific data base for believing that most or all of the offensive radioactive isotopes could be rendered benign using LENR. Remediation of radioactive materials from the current operation of fission reactors by use of LENR reactors is impractical both operationally and economically.

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Excess Heat Might Not Be Entirely From Nuclear Reactions

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During heavy-water electrochemical experiments in the 1980s, Fleischmann and Pons found that more thermal energy came out of their experiments with Pd cathodes than was put in electrically. The excess heat was greater than could be explained by any chemical reactions. Hence, they postulated that the excess energy was due to unexpected nuclear reactions. Now, it is well established experimentally that the amount of excess heat measured in many experiments greatly exceeds what can be attributed to chemistry [1]. For this reason, and also because of numerous reports of nuclear reaction products and energetic radiations, it is widely believed that excess heat is due primarily, and maybe exclusively, to nuclear reactions. Hence, the field is now often called Low Energy *Nuclear* Reactions.

Given the envisioned simultaneous generation of heat and products from nuclear reactions, it is reasonable to expect them to be related quantitatively. The best linking of heat with nuclear products is the correlation of the produced excess energy with quantities of Helium-4. That relationship was discovered by M. Miles, reviewed by T. Bressani in 2000, and well shown in the work of M. C. H. McKubre and his colleagues. The amount of heat and Helium are related quite roughly by 24 MeV per reaction, close to the gamma ray energy emitted during conventional fusion of two deuterons to form ^4He. Despite all the work, the heat-He relationship remains contentious. Few other quantitative correlations between excess heat and nuclear products have been reported.

There is an alternative scenario for production of excess heat and the observation of low levels of nuclear reaction products. It is far from new, but has received relatively little attention. Several theorists have postulated the formation of “compact objects” with sizes and energies between those of atoms and nuclei. If such objects do form, they could account for much of the measured excess heat. Nuclear reactions might follow the formation of the compact objects because of their small sizes, similar to how nuclear reactions occur in muon-catalyzed fusion. The presence of a heavier muon in place of a lighter electron results in atoms with much smaller sizes than usual. This brings nuclei into closer-than-normal proximity and increases conventional fusion probabilities.

This paper is a review of the theories of compact objects and their implications. They include work (listed alphabetically) by J. Dufour, H. Heffner, F. Mayer and J. Reitz, A. Meulenberg and K. P. Sinha, and R. Mills. If formation of compact objects is indeed the initial step in the production of excess heat, the total amount of excess energy E_T depends on the number N_C of reactions that form compact objects, the energy E_C released per formation of a compact object, the fraction f_N of the compact object formation reactions that lead to subsequent nuclear reactions, and the energy E_N released per nuclear reaction:

$$\mathbf{E_T = N_C\{E_C + \Sigma f_N E_N\}}$$

The summation is over the number of subsequent distinct exothermic nuclear reactions. The values of f_N can range from zero (no secondary nuclear reactions) to unity (when a particular nuclear reaction follows each compact object formation event). The fraction of the excess heat due to nuclear reactions, namely ($\Sigma f_N E_N/E_T$), can be as low as zero or as high as nearly unity. The energy gain (E_T/E_{INPUT}) will be determined by the values of the parameters, almost all of which are currently unknown. This additional complexity makes the correlation of overall excess heat with the amount of nuclear products difficult to quantify and, possibly, much more variable.

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Simulation of the Formation of Craters in LENR Cathode Materials

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Many electrochemical Low Energy Nuclear Reactions (LENR) experiments have resulted in the observations of micro-craters in the surfaces of the cathode metals (Pd, Au and others) [1]. Such craters are not known to form in ordinary electrochemical experiments, that is, without the possibility of LENR [2]. Small craters are of interest for scientific reasons. They indicate the fast and local (high power density) release of energy, much faster than can be captured by calorimeters. Knowing crater formation dynamics might contribute to the understanding of LENR, and also constrain theories about mechanisms and locations of LENR. Cratering might also be practically important, since is erodes the cathode material.

No way is known to measure directly the dynamics of crater formation to determine the formation (energy release) time, a key parameter scientifically. Hence, we are using simulations to attempt to learn about the energy production time, the amount of energy liberated, and both the shape and the location of the volume into which energy is released by LENR. There are several commercial software packages, which might be used for the simulations, including ANSYS, ComSol and SolidWorks. We are employing SolidWorks, which permits the initialization of the simulation by designating the cathode material, the release time and total energy, and the geometry of the problem. All of these factors can be varied parametrically in an attempt to produce post-simulation structures similar to those seen in micrographs after LENR experiments. The simulations yield both temporal and spatial distributions of the temperatures that follow from the LENR energy release.

Our initial simulations were done for Pd, using its known heat capacity and thermal conductivity. For one early run, a sub-micron heated volume was positioned 1 micrometer below the surface. For this simulation, 1 microjoule was released into that volume during 0.1 microsecond. Figure 1(left) gives the time history at three points within the 25 micrometer diameter model volume. Figure 1 (right) is a spatial cross section of the heated and nearby region. For this set of parameters, the central energy-release region exceeds the melting temperature of Pd (1828K) early during the energy release time. The region that is melted at the end of 0.1 microsecond is 6.0 micrometers in diameter. We will present the results of simulations of energy releases of 1 nJ to 1 mJ in times from less than 1 nsec to greater than 10 μsec, with a wide range of geometries for the energized volume and its depth below the surface. Estimates of the energy release time and depths are expected to result from the simulation results and their comparisons with experimental micrographs.

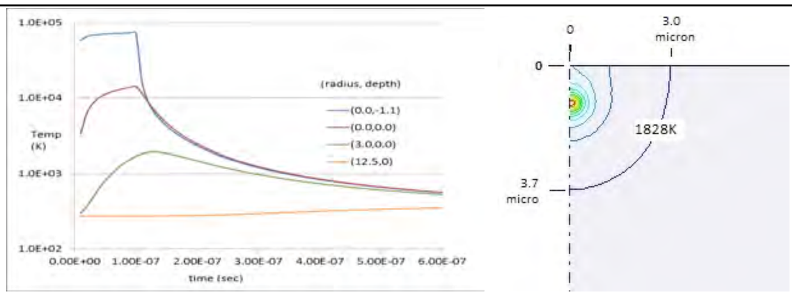

Figure 1. Left: Computed time history of the sample temperatures at (radius, depth) micrometers. Right: Spatial distribution of the temperatures after 1 microsecond.

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Construction of a variable micro-nano-gap instrument for chemical reaction studies and mimicking of possible NAE like structures

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Scanning tunnelling microscope is a versatile instrument to study surface atom structures and surface electron structures. The principles of its operation can be used to develop a variation where two surfaces of micron scale are brought in very close proximity of few atom lengths to each other.. There are many technical challenges involved in such construction that will be reported. Experience in unconventional STM construction [1-3] will be used in this case.

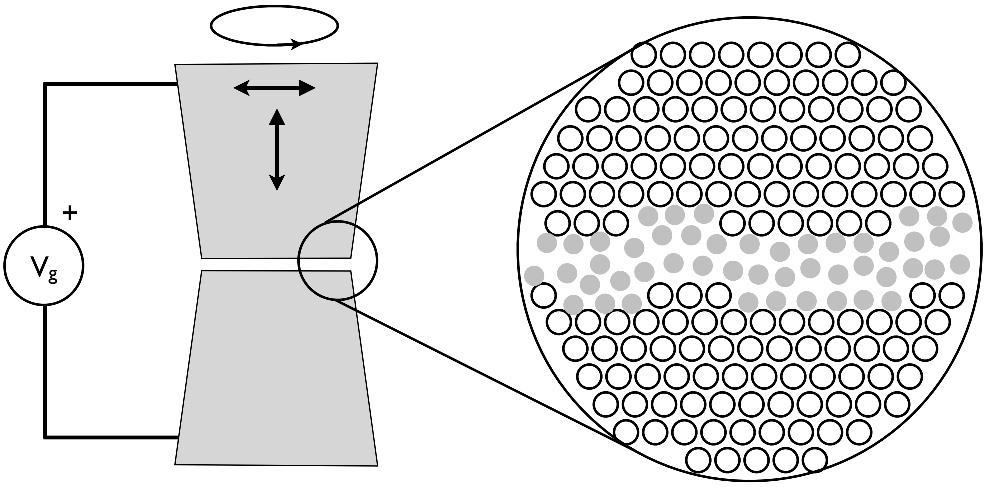

Fig 1. Two microns sized wire ends with mirror like surfaces are brought in alignment of each other in a gas or liquid environment. The wire ends can be moved or vibrated relative to each other on atom scale dimensions.

The most stringent requirements of such instrument will be to be able to create in-situ two surfaces with mirror like surface to be able to reach the shortest gap size (1-5 atoms) without making contact over large are of few microns or even lager areas.

There has still be no experiments in surface science to the authors knowledge were such gaps are exposed to reacting gas or liquids when the gap is slowly reduced and conductivity across the gap is monitored to avoid crashing. There has therefore been no study of the nature of Hydrogen/Deuterium gas that is chemisorbed and is in thermodynamic equilibrium with two Pd hydride surface wire ends. Will there be a gap distance in which H-atoms are not found as bound H_2 molecules but as a lattice of H-atoms. This could be monitored with conductivity measurements. To study this preliminary DFT calculation will be done in order to check this stability limit.

In addition to this means to include in the design radiation detection and caloric measurements will be contemplated and discussed.

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Composition measurements and Imagery of Nanoparticle gas loading experiments as an investigation of LENR reactions

#Anaïs Osouf [1], Kathleen Weichman[2], Bert Stunkard, Tapan Patel, Ziehm Erik[2], Kim Kyu-Jung, Kyungshin Lee[3], George Miley [2,3]
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A key issue for the development of a LENR power unit concerns the changes in nanoparticles during runs. LENUCO LLC is working on such power units and this work on nanoparticle changes is being done in support of that effort. [1] Our experiments have used pressurization of various different nanoparticle alloys with either deuterium or hydrogen. [2] The principal elements in the nanoparticle alloys are Nickel, Palladium and Zirconium with different percentage compositions [2]. We will present the results obtained from study of surface aspects and composition changes in the nanoparticles following runs by two techniques, SEM and SIMS, respectively. The results reported here are from various run times including an extended run that accumulated 40 hours run time.

Until now, both techniques have revealed some important facts. The SEM technique has pointed out a significant average increase in the nanoparticle surface roughness, depending on run time. We also have seen an agglomeration of the particles, mainly in the deuterium pressurized Palladium - Zirconium alloys. Possible explanations for the agglomeration will be discussed, including both physical and magnetic phenomena.

The SIMS runs employ a high resolution time of flight SIMS unit the employs gold ion bombardment. The objective is to obtain information about the elementary composition of the particles, before and after runs of the different alloys. Using the SIMS unit requires mounting the nanoparticles on a carbon tape. So far, the SIMS technique has revealed various elements in post-run particle that are not present in the unused nanoparticles. However, before asserting the creation of any elements due to LENR related reactions, we are in the process of determining the extent of possible contamination in these nanoparticles due to the experimental procedures, e.g. from components in the pressurization system during high temperature operation.

Our poster will present results of our imaging to highlight the differences in composition and surface of the nanoparticles after the experimental pressurization of various nanoparticles with hydrogen/deuterium. We will also address the possible implications of LENR reactions relative to the development of a practical power unit.

[1] G. H. Miley, et al., "A Distributed Power Source Using Low Energy Nuclear Reactions", submitted this conference.

[2] Tapan Patel, et al., "Heat generation from Hydrogen/Deuterium Pressurization of Nanoparticles: Composition and Temperature effect on Heat Output", submitted, this conference.

Speaker Abstract

Evidence for Oppenheimer-Phillips Reactions in Deuterated Palladium and Titanium

Speaker: Dr. Thomas Passell

Date and Time: Thursday, July 25, 8:30 am

Evidence from research papers supporting the hypothesis that the exothermic nuclear reactions providing the observed episodes of excess heat in deuterated palladium (Pd) and titanium (Ti) are Oppenheimer-Phillips (OP) reactions between deuterons and nuclei of the host metal, Pd or Ti and their significant impurities.. Details of the supporting evidence hinge upon neutron activation analysis (NAA) of metal samples before and after production of excess heat episodes plus observation of gamma ray emissions from plausible products of the OP reactions. One example of an OP reaction in palladium is $Pd^{108} + d \rightarrow Pd^{109} + p$, where d and p represent the deuteron and proton respectively. Thus the neutron half of the deuteron has been "stripped away" from its associated proton, leading to the reaction being named the "deuteron stripping" reaction. The strength of the evidence cited in this paper is surprising in light of the high atomic number on the metal atom side of the reaction equation, 46 for Pd and 22 for Ti.. If further confirmed it is clear that some extreme shielding of the coulombic repulsion of the metal atom's high positive charge must be present to allow close enough approach of deuterons to the metal atom nuclei for stripping reactions to occur.

Hydrogen Storage in Engineered Carbon Nanomaterials

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Work at the University of Missouri (http://all-craft.missouri.edu), in an integrated material fabrication/characterization/computational effort, has demonstrated that surface-engineered graphene-like carbons which simultaneously host high surface areas and large fractions of surface sites with high binding energies for hydrogen, created by boron doping, offer a rich spectrum of materials for high-capacity reversible hydrogen storage by strong physisorption. The talk will give an overview of recent results, including: (i) demonstration that boron doping raises the H_2 binding energy from 5 kJ/mol on undoped carbon to 10-14 kJ/mol on the doped surface; (ii) demonstration of a 5.3-liter hydrogen sorption tank, packed with 1.5 kg of high-performance undoped carbon, with a storage capacity of 0.031 kg H_2/kg C (3.0 wt%) at 296 K and 100 bar; (iii) static loading of [H]/[Pd] = 0.81 at 303 K and 200 bar on a Pd sample from SKINR (Sidney Kimmel Institute for Nuclear Renaissance). The relevance of these results for the 2017 DOE targets for vehicular hydrogen storage, and for anomalous heat effects, will be discussed.

Lessons from cold fusion archives and from history

The field is somewhat chaotic. Results are inconsistent and seem contradictory. There is no widely-accepted theoretical explanation. History shows that this kind of chaos is healthy in emergent science. In fields such as plasma fusion there is broad agreement and a solid theoretical basis, but not much progress. We should embrace chaos and celebrate intellectual ferment.

Despite the confusion, the literature does prove the effect is real, and it teaches how to replicate.

The literature includes many failed experiments. There are two kinds: amateur mistakes and noble failures. At Kamiokande they made amateur mistakes such as holding the palladium in their bare hands. To avoid such mistakes you should read textbooks, read the papers at LENR-CANR, and consult with an electrochemist. A noble failure would be Srinivasan spending six months at SRI trying to replicate the bulk nickel-hydrogen excess heat reported by Mills and replicated at BARC. Srinivasan concluded that he had no significant heat, and that the BARC results were in error. Success will only come thanks to failures such as this.

Research has often been dogged by unfounded assumptions which are so widely held no one notices them. An example from the history of genetics is presented. We can only hope that cold fusion is not being delayed by such assumptions.

Development of Pd Incorporated SWCNT Nanostructures for Enhanced Hydrogen Loading

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Hydrogen loading within Pd structures has been a topic under exploration for many decades. Increasing Pd loading in order to obtain β-phase Pd Hydride has been an area of much previous research. Pd embrittlement and thin film delamination due to stresses developed in excess H/D loading remain significant roadblocks towards enhanced H/D loading in Pd structures. We have successfully developed controllable Pd incorporated single walled carbon nanotube (SWCNT) nanostructures which have high surface areas necessary for faster hydrogen adsorption and subsequent absorption. The SWCNT films have been deposited using both electrophoretic deposition (EPD) and dropcasting method. Pd nanostructures have been electro-deposited inside the SWCNT matrix and the final structure shows good adhesion and interesting electrochemical properties. Previously, enhanced hydrogen loading properties were observed for similar structures by Lipson et al. [1]. The hydrogen loading characteristics are under investigation using gas loading and electrochemical loading experiments.

Reference

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Explaining Cold Fusion

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Cold fusion (aka LENR) has been difficult for many people to accept and a challenge to explain. Many attempts have been made to a varying depth, using a variety of different assumptions, while arriving at a variety of different conclusions. Most efforts either conflict with what is known in materials science and/or do not explain all behavior of the phenomenon. As yet, no explanation provides a clear path to achieving reproducible behavior or a method to create a high level of power production. In addition, many of the obvious variables that control the process are not included in the models. This paper will review what is known about cold fusion needing an explanation, summarize the major attempts at proposing an explanation, and provide a model that reduces many of the present limitations of present theory.

The proposed model is based on only a few assumptions, which are:

1. All observed nuclear products result from same basic mechanism operating in the same unique condition in the material, called the NAE.
2. Creation of the NAE follows all laws and rules known to control chemical processes in materials.
3. Once the NAE is created, the nuclear process results in fusion of any isotope of hydrogen in the NAE and releases mass-energy as photons by a unique process.

These assumptions lead to an internally consistent explanation that can be applied to all behavior, can predict testable behavior, and show how the process can be made more reliable, stronger, and better controlled. A logical process will be suggested for connecting the many apparently independent behaviors attributed to LENR, which hopefully can be applied to improving theoretical understanding in the future.

Biography

Dr. Edmund Storms

Edmund Storms obtained a Ph.D. in radiochemistry from Washington University (St. Louis) and is retired from the Los Alamos National Laboratory after thirty-four years of service. His work there involved basic research in the field of high temperature chemistry as applied to materials used in nuclear power and propulsion reactors, including studies of the "cold fusion" effect. Over seventy reviewed publications and monographs resulted from this work as well as several books, all describing an assortment of material properties.

He presently lives in Santa Fe where he is investigating the "cold fusion" effect in his own laboratory. These studies have resulted in thirty presentations to various conferences including the ACS, APS, and ICCF. In addition, over 50 papers have been published including four complete scientific reviews of the field, one published in 1991, another in 1996 and 1998, again in 2000 (www.LENR.org) with the latest in 2010 (Naturwissenschaften). He published a book on the subject in 2007 (World Scientific). In May 1993, he was invited to testify before a congressional committee about the "cold fusion" effect. In 1998, Wired magazine honored him as one of the 25 people in the US who is making a significant contribution to new ideas. He was awarded the Preparata Medal. After retiring from the LANL in 1991, he moved to Santa Fe, NM were he built a home and laboratory in which he continues to study the subject.

Conservation of Energy and Momentum, a Cavitation Heat Event

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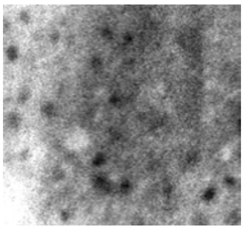
The natural acoustic cavitation bubble process has a destructive end [1], but empowers deuteron cluster implantations into target foils. A cluster of 100 transient high-density deuterons is squeezed first into a condensate cluster. Two (α) of the 100 deuterons are further squeezed to produce one α. The high density compression process is over in a picosecond. The products are He^4 and Δmc^2 which are distributed as heat, Qx, in the D_2O circulation. No long-range radiation products have been found during numerous experiments over a period of 2 decades. The experiments have progressed from 5Kg resonators at KHz to 20 gm resonators at a MHz. Collectively the experiments are pointing to the use of higher resonator frequencies, improving economics, durability, and Qx. The down-sizing of the acoustic resonators as the frequencies are increased show the way to better Qx resonators.

A resonator of a favourable geometry is driven by a MHz piezo in circulating D_2O that focuses z-pinch plasma jets to implant a lattice target with electrons and deuterons. The transient charge separation of the implanted mobile electrons and the relatively static deuterons through their permittivity differences produce attractive image forces [2] across an interface of deuterons and Cooper Pairs, CP, in dense condensates [3]. The transient spherical concentric condensates have additive electric fields and subtractive magnetic fields. The rapid focused squeeze of deuterons towards their shared centre of mass produces concentric condensates of deuterons and Cooper Pairs within the target foil lattice.



The energy of 20 ±10 MeV for one of 31 single events is expressed as a 50 nm diameter crater. The condensate cluster ejecta sites on the Pd foil target surface of a 10^{-12} m^2 area are shown in the FE SEM photo, to the left. The momentum and energy of this 2 particle heat event, evolves around the <u>centre of mass of a remnant deuteron condensate</u> that moves opposite to its <u>α.</u> The particle's relative masses are 98 deuterons and one He^{4++}. The opposing velocities for the 2 particles' total momentum is 0 for the one event. The kinetic energy is $\Delta mc^2=3.8\times10^{-12}$J/event. The calculated velocities for a single event 4.33×10^7 and 8.77×10^5 m/s give the split for energy removal into the D_2O. The number of events collectively, $10^{13}s^{-1}$, are easily accommodated by the survey count of the figure. A D_2O flow-through type calorimeter determined ΔT, gives the total heat-out in watts, Qo. Qx is determined from Qo-Qa. Qa is the measured acoustic input. A series of experiments controlled by the Qa input, maximum Qa of 15 watts, produced 43 watts of Qx.

These MHz experiments were done in a black box so the cavitation sonoluminescence, SL, could be monitored. The oscilloscope measurements of the Qa variable inputs from 1 to 15 watts at a MHz in a collection of 10 data points shows a relationship between SL, Qa, and ΔT, where 4.184 ΔT = Qo and Qo-Qa=Qx, in a linear relationship. SL serves as a tool for monitoring Qx. In the cylindrical resonator measurement of SL by Hamamatsu MPPCs showed that the acoustic SL emission was only 100 ns/cycle in a MHz acoustic input. It leads to a very short activity zone for the z-pinch jets/cycle that implants the target foil only during the multi-bubble SL emission pulse [1]. A natural dispersion of bubbles from a resonator for the multi bubble systems is in 100ns in a MHz. By increasing the frequency to 10 or 20 MHz, the resonators may eliminate the over 90% no bubble activity zone with overlapping SL emission peaks [1] increasing the Qx out-put about ten fold. Scales to 400 watts for a 50 gm resonator.

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Amplification and Restoration of Energy Gain Using Fractionated Magnetic Fields on ZrO_2-PdD Nanostructured CF/LANR Quantum Electronic Component

Mitchell Swartz [1], Peter Hagelstein[2], Gayle Verner[1], Jeffrey Tolleson[1], Leslie Wright[1], Richard Goldbaum[1]
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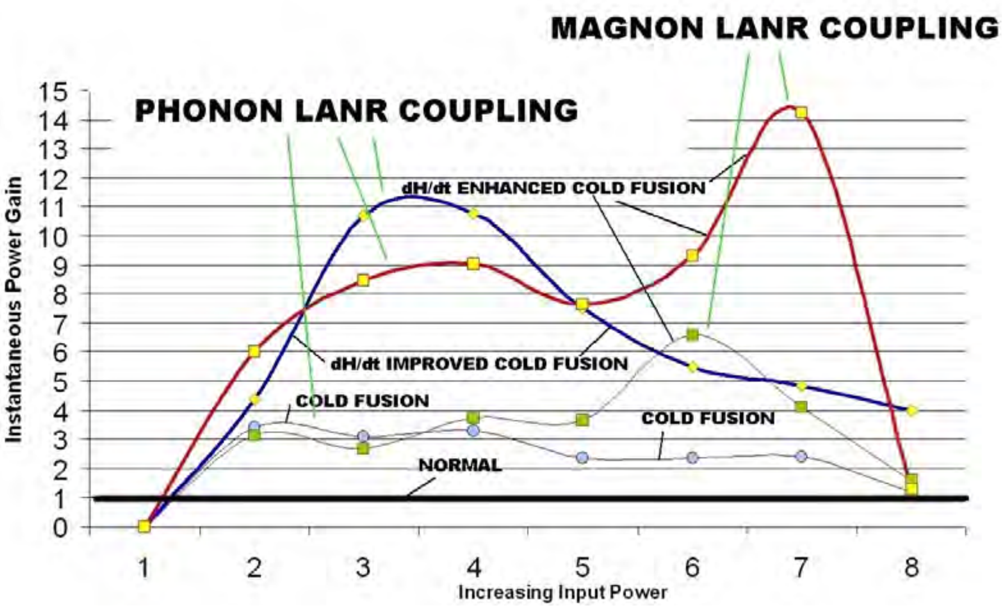
LANR (CF) activated nanocomposite ZrO_2-PdNiD CF/LANR quantum electronic components are capable of significant energy gain [1,2]. For this paper, we examined the NANOR's response to dynamic applied magnetic field intensities. Controls included background, ohmic thermal controls, tests for time invariance, and with and without the applied magnetic field intensities [~1.5 Tesla with 0.1 millisecond rise time]. Power gain was determined by dT/Pin, HF/Pin, and calorimetry. It was discovered that repeated fractionated, magnetic fields were discovered to have a major, significant and unique amplification effect on LANR/CF systems. There were also significant residual late-appearing effects which are complex and demonstrate variable changes in activity suggesting a new material science/nuclear interaction. As importantly, at higher input electrical currents, high intensity fractionated magnetic fields demonstrate their own optimal operating point (OOP) manifold curve. The figure shows the ohmic control ("normal") and conventional CF/LANR operation ("cold fusion"), and the synchronous and metachronous impacts of a fractionated magnetic field intensity. There is an amplified phonon OOP and a *de novo* magnon OOP. The magnon OOP is located to the "right" (at higher input electrical currents and powers) than the conventional CF/LANR phonon OOP. It was discovered that there is also enhanced improvement of CF/LANR (which is synchronous), and that there is improved activity of CF/LANR reactions, which is metachronous and longer-lasting.



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Imaging of an Active LANR Quantum Electronic Component by CR-39

Mitchell Swartz[1], Pamela Mosier-Boss[2], Peter Hagelstein[2], Gayle Verner[1],
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CR-39 has been used by gas and aqueous codeposition LANR systems [1]. This effort examined the impact of ZrO_2-PdNiD CF/LANR quantum electronic devices capable of significant energy gain [2] upon CR-39. Chips were used at different distances, and one was placed directly over the NANOR during the irradiation sequence over several days. Examination of the processed CR-39 chips was done by sectioning each chip into 24 pixels, and a count was done by conventional optical microscopy with side imaging which separates out surface noise from deeper pits.

There was a fall-off in pit count with increasing distance from the operating system. Most interestingly, the CR39 over the device essentially imaged the active CF/LANR device at very low resolution. The scalar counts of the largest and paired pits over the pixels, as we have done previously with positron emission tomography of tumors [3], reveal an "image" of the LANR/CF device elicited only after etching the CR-39 to derive the information "written" thereon. The conclusion is that LANR is a nuclear process, and for this system at this power level, the quantitative amount is measurable, can give a spatial image, and is biologically insignificant. In addition, integrating emission-sensitive elements can be used to image the active site of LANR systems.

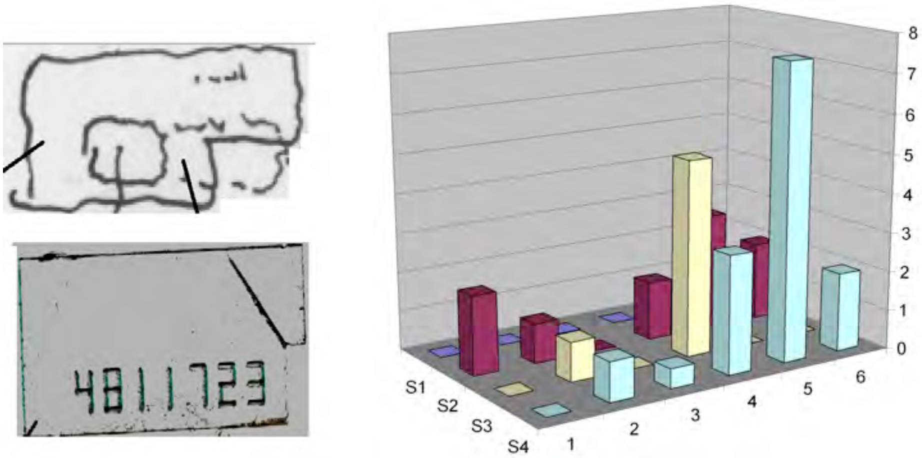

Fig. (left, top) The NANOR is shown below the chip in a notebook drawing., with the solid region believed to be the active area at the time. (left, bottom) The actual CR-39 chip which was placed above the NANOR. (right) Histogram of large pits on CR39 vicinal to NANOR-type LANR component pixel by pixel. A count was made over the left hand rectangular area of the chip, up to where the width changes.

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Nuclear Products of Cold Fusion by TSC Theory

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Anomalous excess heat without corresponding nuclear radiations have been claimed by cold fusion experiments with metal-deuterium systems (heat/^{4}He correlation by Miles, McKubre, et al., very weak alpha-particles by Roussetskii and Lipson, et al, very weak neutron emission by Boss, Takahashi, et al) since 1990s. These claims are challenging to making theoretical models to elucidate underlying physical mechanisms.

The author has elaborated the TSC (tetrahedral symmetric condensate) theory for either the metal-D systems (ACS LENRSB Vol.1 and Vol.2, ICCF17, etc.) or the Ni-H systems (JCMNS Vol.9, JCF12, ICCF17, etc.). The author's past effort has been concentrated on the initial and intermediate states of TSC condensation and strong interaction processes, and the prediction of nuclear products by the final state nuclear interactions have not been deeply studied. In the JCF-13 paper (Nucleon Halo Model of ^{8}Be* by Takahashi-Rocha), we have started the study on the final state interaction of 4D/TSC fusion.

This paper reviews and discusses predictable primary and secondary nuclear products as its brief summary is seen in Table-1.

Why so radiation-less results?

	Claims by Experiments	Predictions by TSC Models
MDE (Metal Deuterium Energy)	Heat: 24±1MeV/^{4}He (Miles, McKubre, et al) Weak alpha-peaks (Lipson, Roussetskii, etc) Weak neutrons (Takahashi, Boss, etc.) *X-rays burst* (Karabut, et al.)	23.8MeV/^{4}He by 4D/TSC fusion with low-E alphas (46keV) Minor alpha-peaks by nucleon-halo BOLEP minor decay channels High-E neutron by minor triton emission *BOLEP* in ca.1.5keV
MHE (Metal Hydrogen Energy)	Heat w/o n and gamma unknown ash (Piantelli, Takahashi-Kitamura, Celani, etc.)	4H/TSC WS fusion 7-2MeV/^{3}He and d Very weak secondary Gamma and n Ca. 10^{-11} of ^{3}He and d

2

Technova Inc. テクノバ6201-R-

Table-1: Claimed anomalous heat phenomena and predictions of TSC theories

Anomalous Exothermic and Endothermic Data Observed by Nano-Ni-Composite Samples

A. Takahashi [1, 2], A. Kitamura[1, 3], R. Seto[1], Y. Fujita[1], H. Sakoh[3], Y. Miyoshi[3], A. Taniike[3], Y. Furuyama[3], T. Murota[4] and T. Tahara[4]

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This is an experimental paper summarizing the observations of anomalous data on excess heat, D(H)-loading and abrupt desorption with endothermic heat sink in Ni-nano-composite samples under D(H)-gas charging at both room and elevated temperatures, done by Kobe-Technova group in 2012-2013.

Referring to our JCF12 paper (Y. Miyoshi et al., JCF-12-1) on Pd_1Ni_7/ZrO_2 samples, experimental procedure and results reported for Ni/ZrO_2, $Cu_{0.21}Ni_{0.21}/ZrO_2$ and $Cu_{0.08}Ni_{0.36}/ZrO_2$ samples (partially reported in our JCF13-15 paper by Sakoh et al.) will be summarized. We have reanalyzed time-dependent data for speculating heat releasing mechanisms during the long (several weeks) lasted phase of D(H)-loading-into-nano-metal. It seems that competing process of D(H)-gas sorption and desorption at the surface of nano-powders would be attributed to the mechanism.

Burst-like heat peaks of η-values (in unit of eV per D(H)-take-in/out) were observed with anomalously high values reaching 600 eV/H-sorption, and with smaller η-values for isotopic D-sorption than H-sorption, at 573K. Integrated heat values for several-week runs were reached at the levels of ca. 800eV/atom-Ni for $Cu_{0.08}Ni_{0.36}/ZrO_2$ samples, which were about 10 times larger than those of Ni/ZrO_2 samples and about 4 times larger than those of $Cu_{0.21}Ni_{0.21}/ZrO_2$ samples, at temperatures of 523 to 573K.

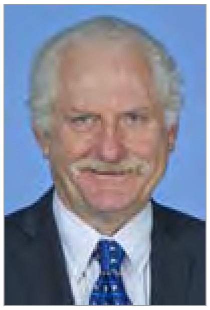
In the pre-treatment runs at 573K, very anomalous abrupt desorption phenomenon with rapid decrease of loading ratio and heat-level (heat-sink phenomenon) were repeatedly observed for all Nano-Ni composite samples. Observed heat-sink energy per D(H)-desorption was around 50-80 eV, which is too large to be explained by H(D)-bonding energy to any metal. Displacement/knock-on of plural Ni-atoms by a proton/deuteron desorption might cause ca. 40 eV per Ni-displacement for energy absorption. If so, we may speculate that vacancies/defects would be formed in Ni-core-lattice and multi-atomic H(D)-clusters would be trapped there in the post-pre-treatment D(H)-charging runs. (These clusters might be seeds to induce anomalous heat effect, which might be some nuclear origin, for further main runs of D(H) charging by elevating temperature above room temperature.)

After the pre-treatment, we took data by elevating temperature from 373K up to 573K. We did not observe the anomalous 'abrupt' heat sink events by desorption and did observe excess power showing rather monotonous evolution. We need repeated experiments to conform the phenomenon.

No visible increase of neutron counts (by ^3He counter) over natural background has been observed until now. Very slight increase of gamma-ray counts (by NaI counter) was sometimes recorded, but we need spectral and heat-cross-correlation-based confirmation in further scaled-up experiments (See our report from A. Kitamura et al in this Conference).

Biography

James Truchard



Named an Innovation Agent by Fast Company, James Truchard, president and CEO, cofounded National Instruments in 1976 and has pioneered the way scientists and engineers solve the world's grand engineering challenges.

As one of Forbes' America's Favorite Bosses, Dr. James Truchard, commonly known around NI as Dr. T, has led the company from a three-man team to a multinational organization recognized as a Fortune 100 Best Places to Work and one of the top 25 "World's Best Multinational Workplaces" by the Great Places to Work Institute.

Under Truchard's leadership, the company's long-term vision, known as the 100 year plan, and focus on improving the world by providing tools that accelerate productivity, innovation, and discovery, has led to strong, consistent company growth and success of its broad base of customers, employees, suppliers, and shareholders. Learn more about the NI company story at ni.com/company.

Elected to the Royal Swedish Academy of Engineering Sciences and the National Academy of Engineering, Truchard has also been inducted into Electronic Design's Engineering Hall of Fame.

Additionally, Truchard has been recognized with the Woodrow Wilson Award for Corporate Citizenship for his community involvement with organizations including: the Engineering Foundation Advisory Council, The University of Texas at Austin Chancellor's Council, Austin Software Council, and FIRST Robotics.

Truchard's personal passion for gardening and photography has led him to writing a gardening book that he plans on giving to non-profits for their use fundraising.

Truchard holds a doctorate in electrical engineering, as well as a master's degree and bachelor's degree in physics, all from the University of Texas at Austin, where he has been recognized as a distinguished alumni. Truchard earned his master's and doctorate degrees while working full-time as the managing director of the acoustical measurements division at the UT Applied Research Laboratories.

Theoretical Study on the Nuclear Reactions in Solids by Calculating Quantum States of the System Including Two Species of Charged Bosons in Ion Traps.

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We can estimate the nuclear reactions in solids by solving the problems of the charged bosons trapped in the crystal. They are approximately characterized by the harmonic potential around the trapped site and repulsive potentials between bosons [1]. The nuclear reaction rates are obtained from the overlaps of the wave functions.

In this study, we have considered the new method how to perform the numerical calculations for the problems on the mixtures of the positively charged bosons in ion trap, which was proposed by Kim et al. [2, 3]. In their problems, the electro-static potential and the number density of each boson are linked with each other and we cannot solve it by usual simple method. Therefore, we have introduced self-consistent iterative calculations for the coupled two equations corresponding to the two species of positively charged bosons. In this method, the Schrödinger's equation and the Poisson's equation were solved alternately.

The numerical calculations for the systems including deuterons and Li ions, deuterons and Ni ions and some other cases have been done. Through the calculations, the dependency of the wave functions on the valence or mass of the charged bosons were obtained. The nuclear reaction rate for each case was also obtained.

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Subbarrier Processes in LENR for Particles in Correlated States at Action of Damping and Fluctuations

#V.I.Vysotskii, M.V.Vysotskyy

It is well known that the presence of high and wide Coulomb barrier is the main obstacle to LENR. The method of the formation of coherent correlated state (CCS) with correlation coefficient $|r| \to 1$ of a particle, which can be used to giant increase of the transparency of this potential barrier

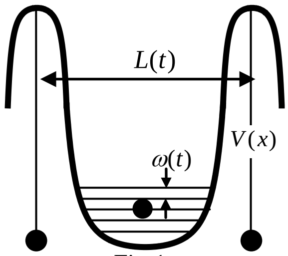

Fig.1

from very small values $D_{|r|=0} \approx 10^{-70}...10^{-1000}$ up to $D_{|r|\to 1} \approx D_{r=0}^{\sqrt{1-r^2}} \to 1$ was considered in [1–3]. The uniqueness of this method is connected with the fact that the transparency of the barriers ("walls" of a potential well with a particle) and the probability of LENR can be increased using a simple procedure of CCS formation: periodic modulation of the well width for the same barrier height $L(t) = L_0(1+g\cos\Omega t)$, $\omega(t) = \omega_0(1+g\cos\Omega t), g<<1$. The physical mechanism of the increase of barrier transparency for a CCS is associated with synchronization and periodic phasing of fluctuations of momentums $\Delta\vec{p}_n(t)$ of different eigenstates in the given quantum-mechanical system. The presence of external stochastic perturbation can violate the phase relations between different eigenstates and may affect the formation of the CCS, determining both the rate of the increase in |r(t)| and the value of $|r_{max}|$. Another essential negative factors are the damping of these oscillations and anharmonicity at growth of amplitude of these oscillations at periodic modulation.

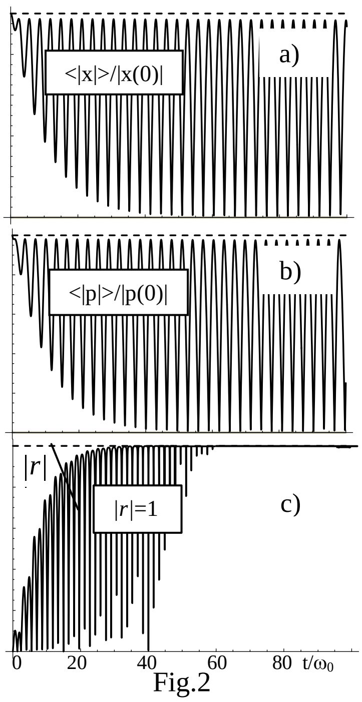

Fig.2

We consider peculiarities of the formation of CCS of a particle in a periodically modulated potential well with damping for various types of stochastic perturbation. It was shown that at the absence of stochastic perturbation, an optimal relation $g = 2\gamma$ exists between the damping coefficient γ and the modulation depth, for which the "extrinsic" characteristics of the oscillator (amplitudes $<|x|>$ of "classical" oscillation and the momentum $<|p|>$ of a particle) remain unchanged and small, while the correlation coefficient rapidly increases from $r = 0$ to $r \to 1$; this corresponds to completely CCS (Fig.2,a,b,c). It was shown that for optimal condition $g < 2\gamma$ the presence of a stochastic delta-correlated $< f(t_1) f(t_2) >= 2S\delta(t_1 - t_2)$ force $f(t)$ substantially affects the rate of increase of normalized amplitude of oscillations, as well as the absolute value of correlation coefficient with time, but does not affect the final value $|r| \to 1$ and giant increase of the transparency $D_{|r|\to 1} \to 1$! These effects can be used for LENR optimization in real physical systems at action of damping and fluctuations.

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The Possible Reasons of External X-Ray Radiation of LENR Installations

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In numerous experimental LENR-related works were presented the results of investigation of hard electromagnetic radiation emitted from working chamber when palladium or nickel samples were exposed to deuterium and hydrogen. Such effects were observed regularly during electrolysis, gas discharge, thermocycling etc. Intensity of this radiation was uncorrelated with heat generation and isotope changes into working chamber. Moreover, this radiation was frequently registered in absolutely abnormal systems - e.g. behind the "black" screen (wall) which thickness much surpasses absorption mean free path of radiation.

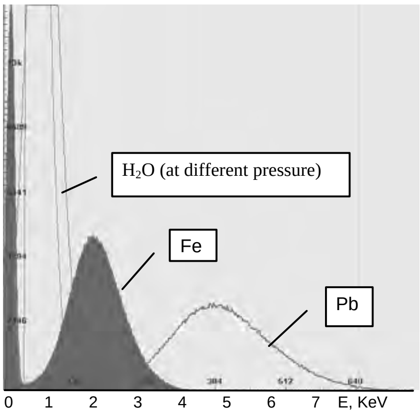

Fig. 1

These abnormal results are similar to the results of investigation of external X-Ray radiation generated on outer surface of closed chamber at cavitation of liquid [1,2]. In these works the radiation processes have been associated with a liquid (machine oil or water) jet moving through the narrow channel. It has been found during detailed investigation that the outer surface of the working chamber are sources of intense X-radiation, generation of which is related to cavitation processes in the liquid jet bulk and subsequent excitation of internal shock waves. Interaction of these shock waves with external surface atoms of water jet, metal tube or thick screen leads to external X-Ray generation. The frequency (energy) of X-radiation depends on the types of atoms on a radiating surface (for a jet, it is water; for a channel, the metal atoms on the surface (e.g. Fe, Cu, Pb, etc) and increases with the increase of atoms charge (Fig.1). The total X-ray activity of working chamber reaches Q≈0.1 Ci.

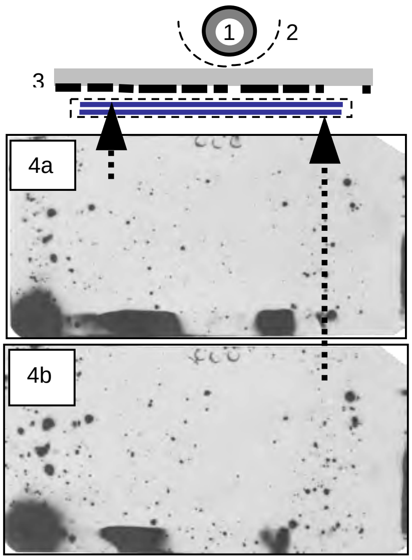

Fig. 2

It was found for the first time that the impact of shock acoustic waves 2 (Fig. 2), which are formed in the air as a result of cavitation in water jets 1, on distant thick screen 3 (made of stainless still with stickiness 3 mm) leads to the generation of a quasi-coherent directional X-ray emission from the back side of screen 3, that was registered by two films 4a,4b stacked to each other! The spatial parameters of this radiation depend on the shape and size of the screen and characteristics of shock wave.

There is a high probability that X-Ray phenomena observed at explosion of cavitation bubbles and connected with the interaction of cavitation induced shock waves with outer surface of working chamber or screen are similar to X-Ray phenomena, which take place during generation of similar shock waves at fast formation of numerous micro-cracks at loading and interaction of hydrogen or deuterium with metals matrix during electrolysis, gas discharge or thermocycling. These processes are discussed also.

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Progress in Diamond Sensor Development for Use in LENR Experiments

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Electronic grade single crystal diamonds have recently become available, and the characteristics of these diamonds are ideal for the detection of various types of nuclear radiation. Previous work demonstrated the usefulness of diamond detectors in low energy nuclear reaction systems and exposed their fragile nature when used *in situ*. This work describes the use of different material combinations and fabrication techniques in an effort to improve the sensitivity and durability of these diamond sensors. We have successfully fabricated Palladium electrode diamond sensors using two additional material combinations. Their behavior was characterized using common I-V techniques. The spectroscopic response of the sensors was calibrated using a Pu-239 alpha source.

Sporadic Neutron Production by Pressure-Loaded D/Ti Systems under High Rates of Temperature Change

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The mechanisms of low energy nuclear reactions (LENR) phenomena are poorly understood. If these phenomena are the consequence of commonly understood nuclear interactions, they should produce some nuclear byproducts such as gamma rays, neutrons, or charged particles. The unpublished results of a 1991 thermal shock experiment with high D/Ti loading observed a high rate of neutron emission while a recent attempt to recreate the 1991 results showed no evidence of neutrons produced by interactions within the D/Ti lattice. This work recreates the 1991 experiment and continues the previous recent investigation with improved methodology. In addition to control of deuterium pressure, system temperature, and duration of cryogenic exposure, this new setup also offers continuous data-logging and automated analysis routines. Although it has been suggested that the appearance of LENR phenomena is intimately related to specific characteristics of the material, the experimental system described herein has recorded anomalous numbers of neutrons on several occasions using materials of unspecified origin. Helium-3 data indicate neutrons are periodically emitted by reactions occurring within the D/Ti lattice, with a recorded maximum of 1800 neutrons per second, but these neutron releases do not appear to coincide with thermal shock events.

Energetic Particles Generated in Pd+D Nuclear Reactions

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Abstract

Low energy nuclear reactions (LENRs) are now believed to be one of the best future energy sources – clean, cheap and sustainable. In addition, the LENR energy is also the only solution to solve all the environmental problems, such as the greenhouse effects, environmental destructions and the heavy air pollutions happened recently in China.

CR-39 plastic nuclear track detectors (PNTDs) are the most useful nuclear track detectors in physics research. An important physical quantity in CR-39 work is the linear energy transfer (LET) - the linear density of energy lost by a charged ionizing particle traveling through matter, with units of keV/µm or MeV/cm. LET depends on the nature of the incident particle and the material traversed and governs the characteristics of the nuclear track in CR-39 detector. CR-39 detectors are sensitive to high LET particles (≥ 5 keV/µm water) and can measure charged particles directly and neutrons through secondary charged particles. The LET spectrum method using CR-39 detectors is so far the best one for high-LET particles research. Therefore, CR-39 PNTDs have been used for investigation on condensed matter nuclear sciences (CMNSs), including LENRs.

The former US Navy group and Tsinghua group conducted Pd+D experiments successfully and accumulated abundant experimental data recorded with CR-39 detectors. However, so far the physical results for the Pd+D nuclear reactions presented and/or published are mainly focused on the photos of nuclear tracks in CR-39 detectors and the statistics for the track parameters. Those approaches are important but can not provide the fundamental physical quantities – charge, energy and energy loss for each particle measured. Strict quantitative methods should be introduced for the data analysis of LENR particles. So far, the advanced LET spectrum method employing CR-39 detectors is definitely the best solution to obtain strict quantitative results for LENRs experiments. Any reliable LENR theories, reactors and products related to LENR energy can be obtained only based on the solid fundamental experimental research of LENRs. Therefore, it is a significant task for analyzing the Navy group's original data of LENRs using LET spectrum method.

This paper introduces the LET spectrum method using CR-39 detectors and the analysis procedures for the original data recorded with CR-39 detectors by the former Navy group, presents main results on LET spectra and charge distributions obtained using LET spectrum method, discusses the experimental spectra and the observed phenomenons, including the triple alpha particles generated by high energy neutrons produced in LENRs. The generation of high energy neutrons is a strong evidence of nuclear reactions. Novel methods and detectors for LENRs research are also discussed.

Key words: LENR particles, CR-39 detectors, LET spectrum method, LET spectra for Pd+D experiments