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What is Needed in LENR/FPE Studies

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ICCF16 marks nearly 22 years of research into the phenomenon first called "cold fusion". This new field has expanded in breadth to the point that numerous acronyms compete to describe overlapping effects. Two of these are: LENR (Low Energy Nuclear Reactions) and its subset FPE (the Fleischmann Pons Effect). Research to elucidate the basic processes and shed light on mechanisms has proceeded effectively continuously since March 1989 at SRI and elsewhere, and diligently and "as time and funds permit" at numerous other accomplished institutions worldwide.

It is now clear to a well-informed but regrettably small group of scientifically-interested individuals that the deuterium-palladium systems conceals a heat source with energy exceeding by several orders of magnitude mechanical, lattice storage or chemical energy effects. Evidences of possible dd fusion products have been widely and numerously observed, at least partially ratifying the original speculative designation of "cold fusion". The effect, however, is apparently not limited to deuterium as a fuel, to helium as a product or to palladium as a matrix, hence the classification of the field as Condensed Matter Nuclear Science (CMNS) to differentiate these "new" effects from those observed in the rarified environments of particle and plasma physics.

The materials-related issues associated with the so-called irreproducibility of CMNS effects presents the greatest barrier to the advancement and acceptance of the field. Precisely because we are dealing with condensed matter, micro-structural and micro-impurity control is difficult and expensive, requiring specialized equipment, control and skill. Problems of similar scale (and origin) have been faced and overcome in the past in the development of technologies having similar significance for

mankind. Two (of many) examples are: the development of solid-state semiconductors; implementation of conventional nuclear power (and weapons).

Absent another Bell Labs or Manhattan Project how should the CMNS field best proceed? Several overlapping options will be discussed. It is well within the capability of "mainstream" scientists and engineers in academia, and in national and private laboratories to resolve the materials issues and the questions of whether or not specific products are or are not present. Without funding they will not be encouraged to do so; without (a higher degree of) acceptance, adequate funding will not be made available. This paper will address various options and strategies to resolve this logical dilemma.

What is Real About Cold Fusion and What Explanations are Plausible?

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Experimental observations are now available that allow rational theories and models about the cold fusion effect to be tested. Some of this information is summarized and used to draw logical inferences about the requirements a plausible theory must satisfy.

Hundreds of ways to describe how the process might work have been published and discussed. Most early ideas are not useful because they were based on insufficient information. Therefore, these will be ignored even though they have historical interest. Many ideas have advocates who are not interested in discussing other possibilities, being content to explore their own idea in depth. This talk is not a critique of such approaches, but will try to present a collection of requirements all theories must acknowledge. If a proposed theory is not consistent with these requirements, the originator of this theory can make the necessary changes.

In addition to being consistent with a wide range of observations, a theory must fit the accepted understanding of how materials are known to behave under conditions applied during successful cold fusion studies. Furthermore, if energy is produced by such reactions, it must also be consistent with how an application of similar energy by normal means is known to behave.

While cold fusion is not like hot fusion, it is, nevertheless, part of a fabric of knowledge and needs to be treated as such.

OV-03

The Status of Cold Fusion

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Before a plausible theory can be developed and before useful addition to knowledge can be undertaken, the present knowledge on which the claim for cold fusion rests needs to be understood. This knowledge base has grown to be very complex during the last 21 years and now provides enough replicated and correlated behavior to show most claims to be valid.

The major discoveries will be described and their implications suggested. These implications suggest paths to plausible theories and productive experimental approaches.

The present knowledge base includes information about anomalous power at significant levels, its correlation with helium production, formation of tritium and transmutation products, and emission of various types and energies of radiation.

Evaluation of Vibrator on Production of Helium and Energy in the "Solid Fusion"

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In the present paper, the apparatus has been improved for the anomalous heat production and detection condition of "Solid Fusion Reactor". A coil vibrator was set under the stainless steel reactor, which is capable to vibrate the reactor and the inside powder to improve the contact rate of the powders and D_2/H_2 gas during gas loading (Jet-Fusion) and the following skirt-fusion. On the other hand, an outer low vacuum chamber was applied to improve the cooling condition (namely, decrease the thermal loss). As results, the anomalous heat and the released Helium data detected by mass spectroscopy of $ZrO_2 \cdot Ni_{30}Pd_5$ powder were presented as the evaluation factors.

Modeling Anomalies in Nano-Palladium D(H) - Gas Loading Experiments

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The Kobe group continues to study underlying physics in the observed anomalies in D(H)-gas loading experiments with nano-metal(M)-particles/metal-oxide samples[1-3], since 2008.

The observed anomalies are summarized as:

1. Very rapid MD(H)x over-full loading (x>1) under near "zero pressure" of D(H)-gas is reproducibly attained for Pd/ZrO_2 (PZ) and $Pd/Ni/ZrO_2$ (PNZ) samples.

2. Anomalously large released heat (0.6-2.0 eV/D(H)) in Phase-I period for PZ and PNZ samples, compared with known value about 0.2 eV/D(H) for bulk Pd metal (PP) sample, is reproducibly observed. Energy gain (sorption-energy/desorption-energy) for D is near 10.

3. By the forced oxidization (several % PdO formation) of used PZ and PNZ samples, surprising recovery of performances on loading ratio (x>1) and heat release level (0.9-1.5eV/D(H)) has been repeatedly observed, while by the de-oxidization the performances got back to the near bulk ones (0.25-0.28 eV/D(H), x=0.4-0.7) for PZ sample.

4. To study dynamics of D(H)-sorption (adsorption /absorption), time-dependent measurements of evolutions for D(H)/M ratios and η-values (energy per a D(H)-sorption) have provided interesting data with very large isotopic effects, which suggests some "nuclear effects".

We discuss mechanisms to answer why such "chemical + nuclear" anomalies take place in "mesoscopic" particles confined in metal-oxides. A special role of PdO surface layer is modeled to scope the generation of surface sub-nano-holes (SNH). SNH may trap D(H)-clusters on surface with deep adsorption potential, providing seeds of 4D/TSC-induced 4d fusion (23.8MeV/^{4}He-product).

It enhances D(H)-diffusion into Pd lattice sites of nano-particle, and at the end of Phase-I realizes the x>1 state with "very deep (1.5-1.8 eV for PZ)" global trapping potential (GPT) of "mesoscopic catalyst". In GPT there holds local shrunken Bloch potentials for MD(H) lattice to induce the non-linear D(H)-oscillation mode that enhances very much the TSC (tetrahedral symmetric condensate) formation probability in the nano-particle.

References:

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[2] Akira Kitamura, Akito Takahashi, Yu Sasaki, Yuki Miyoshi, Akira Taniike, Reiko Seto and Yushi Fujita: "Heat Evolution from Pd Nanopowders Exposed to High-Pressure Hydrogen Isotopes and Associated Radiation Measurements", J.P.Biberian, Ed., JCMNS, Vol.5, 2011, Under publication.

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Mechanisms for Heat Generation during Deuterium and Hydrogen Loading of Palladium Nanostructures

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Recent studies on deuterium loading of palladium nanostructures demonstrated consistent and repeatable anomalous heat production [1-4]. Our group has investigated the effect and confirmed anomalous heat production in alumina powders containing highly dispersed Pd nanoparticles.

Further investigation at different pressures and loading rates has shown a clear association between exothermic and endothermic features along with overall heat production upon exposure of the material to deuterium and hydrogen gases. This association provides insight into underlying mechanism and the crucial question as to the origin of the anomalous heat.

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[2] Y.Arata, Y.Zhang, X.Wang, ICCF-15, 2009, Rome, Italy
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[4] T.Hioki et al., ICCF-15, 2009, Rome, Italy

Fabrication, Characterization, and Evaluation of Arata Style Alloys

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Zirconium-Nickel-Palladium alloys have been reported to generate a greater amount of heat with deuterium than with light hydrogen in gas loading experiments.[1] What is intriguing about these experiments is the long-term heat observed. Others, using commercial materials of similar composition, have been unable to observe long-term heat.[2]

We also have been unable to observe long-term heat in the commercial materials. Furthermore, when tested using our protocol of measuring both the heat during pressurization and evacuation [3], the commercial materials do not show much, if any, excess heat.

We made a large series of materials at NRL along the lines of Arata. The results of these experiments and characterization of our alloys as compared to Arata's reported results will be presented.

References:

[1] Y. Arata, Y. Zhang, and X. Wang, "Production of Helium and Energy in the 'Solid Fusion' ", in 15th International Conference on Condensed Matter Nuclear Science. 2009. Rome, Italy.

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Is the Excess Heat from Gas Loading Consistent with D-H Exchange?

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Gas loading of sub-nanometer particles of Pd supported or encapsulated on various oxide substrates can generate a greater amount of heat with deuterium than similar loading with light hydrogen gas.[1] One suspected source of this additional heat is the exchange of D for H in -OH or H_2O present on the substrate. To assess whether such an exchange can explain the observed heat, spectrometric techniques were applied to examine the magnitude and kinetics of the D-H exchange process and correlate this to the quantity and kinetics of the heat produced as measured by calorimetry.

Mass spectrometry was performed on the gases extracted during the pump-out phase of the gas loading experiments. A quantitative measure of the magnitude of the exchange was obtained and evaluated as to its contribution to the excess heat observed. However, the kinetics of the H-D exchange process could not be monitored during the pressurization pulse, where most heat is produced.

Other *in situ* measurements such as Fourier Transform InfraRed (FTIR), Nuclear Magnetic Resonance (NMR), and Raman spectroscopies can measure the D-H exchange kinetics. Diffuse reflection FTIR of lightly packed powder was used as an analogy for the calorimetric measurements. Absorption by water and hydroxyl bond vibrations provided a direct measure of the D-H exchange kinetics on various substrates. NMR and Raman spectroscopy was performed to explore other possible sites for D-H exchange, and to obtain the kinetics for those exchanges. If the D-H exchange kinetics from these *in situ* measurements does not match the kinetics of the heat produced, then other sources of the observed, excess heat must be sought.

Our interpretation of the results from all these complimentary measurements will be presented.

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[1] David A. Kidwell, Allison E. Rogers, Kenneth Grabowski, and David Knies,"Does Gas Loading Produce Anomalous Heat?", 15th International Conference on Condensed Matter Nuclear Science, Rome, Italy October 5-9,2009 Approval # 09-1226-3219.

GL-06

Nuclear "Ash" and Particle Detection in Gas Loading Experiments

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Gas loading of palladium particles <2 nm in size reproducibly generates anomalous heat. This heat is produced in the presence of deuterium but not in the presence of hydrogen. Control experiments have ruled out heat arising from impurities present in the deuterium, but absent in the hydrogen. Because the system is simple and the process mostly reversible, all extra heat must be of chemical or some other origin.

There should be some signature attesting if this heat is of non-chemical origin. As the exothermic reactions are produced quickly in our system, we can synchronize measurements to the gas-loading pulse time interval, and reduce background. We have done measurements in a specially built apparatus and have found essentially no convincing evidence of nuclear particle or X-ray emissions commensurate with the gas loading pulse. On the other hand, we have seen large light pulses that we attribute to fracturing the silicoaluminate matrix during evacuation and nanoparticle growth during pressurization.

We will review our method of gas loading and why we believe that our approach is ideal to measure anomalous heat and present recent heat measurement results. Results from He^4 measurements and their correlation with observed heat will be presented, and details of He^4, X-ray, light, and particle detection along with the pitfalls of their measurement will be discussed.

Excess Heat in a Long Thin Palladium Tube at Room Temperature using Gas-Loading Method

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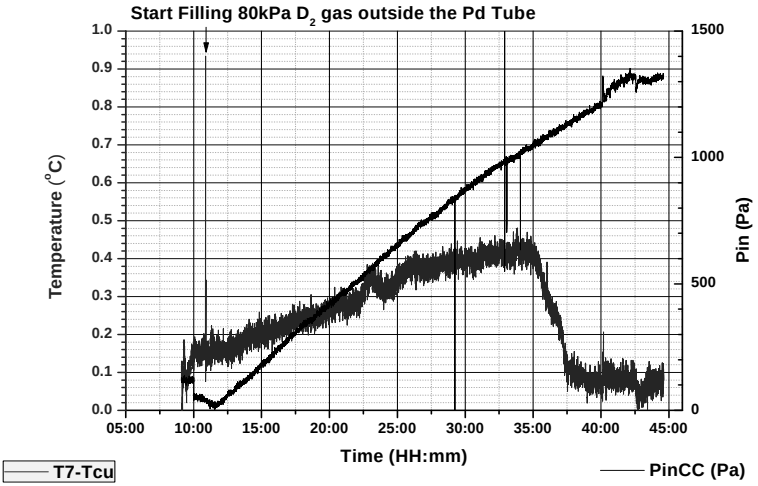
Gas-loading experiments using deuterium and palladium have been conducted for 20 years at Tsinghua University since 1989. It evolved from low temperature-high pressure (77K, 9 atm.) to high temperature-low pressure (140^{o}C, 80kPa). The most important finding was the correlation between excess-heat and the deuterium flux at the temperature higher than the boiling temperature [1]. The configuration evolved from thin Pd film to long-thin Pd tube. The length of the palladium tube evolved from 26 mm to 400 mm. The number of palladium tubes evolved from 1 to 5. The direction of deuterium flux evolved from outward to inward through the thin wall of the palladium tube. The calorimeter evolved from the Seeback type to Comparative calibration type. A new result of correlation between excess heat and deuterium flux at room temperature would be presented in details.



A short copper tube is welded between two pieces of palladium tube. The above figure shows the temperature difference between Pd and Cu tubes while the deuterium pressure is 80 kPa outside the Pd tube. The pressure inside the Pd tube is shown by the right ordinate (black). The first spike of temperature difference (red) in 40 seconds is caused by the heat of formation (~0.2 eV per d-atom in Pd) and the slow ramp-up in 24 hours is induced by the deuterium flux. A qualitative calculation based on this fast spike and slow heating process induced by deuterium flux shows that the excess heat must be non-chemical origin.

Reference:

[1] Xing Z. Li, Bin Liu, Jian Tian, Qing M. Wei, Rui Zhou and Zhi W. Yu, J. Phys. D: Appl. Phys. 2003, 36, pp 3095-3097.

"Excess Heat" Triggering by "Pumping Effect" in a H-Pd Gas Loading System

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"Excess heat" especially the one with high power density has been a major destination for LENR or CMNS researchers. "Pumping effect" is one of the methods that could induce a reproducible "excess heat" found by Li and Tian in 2002 [1,2]. But the excess heat with high power density, for example more than 10W/cm^3 Pd was hardly repeated for a relatively long period of time. In order to resolve this problem we redesigned the old experiment system and equipped it with a high quality molecular turbine pump. And then a series of experiments for searching "excess heat" were done in nearly six years. In the just recent we got a little satisfactory "excess heat" result triggering by "pumping effect" in a H-Pd gas loading system: When the input power was 10^{-4}W we got 0.4 W output. The more interesting thing was that the loading ratio at that time was only about 0.014, which implied that a certain gas loading ratio needs a certain "excess heat" condition for heat releasing. The maximum "excess heat" power density was more than 50W/cm^3 Pd. The abnormal effect lasted for about 100 seconds and released nearly 50 J "excess heat" in burst. A possible mechanism is proposed here: The heat burst might be caused by interaction of hydrogen atoms which are transported from $-\beta$phase of PdH to $-\alpha$phase due to the pumping. The collisions would happen inside the overlap region of two phases where a selected resonant tunneling fusion [3] might appear.

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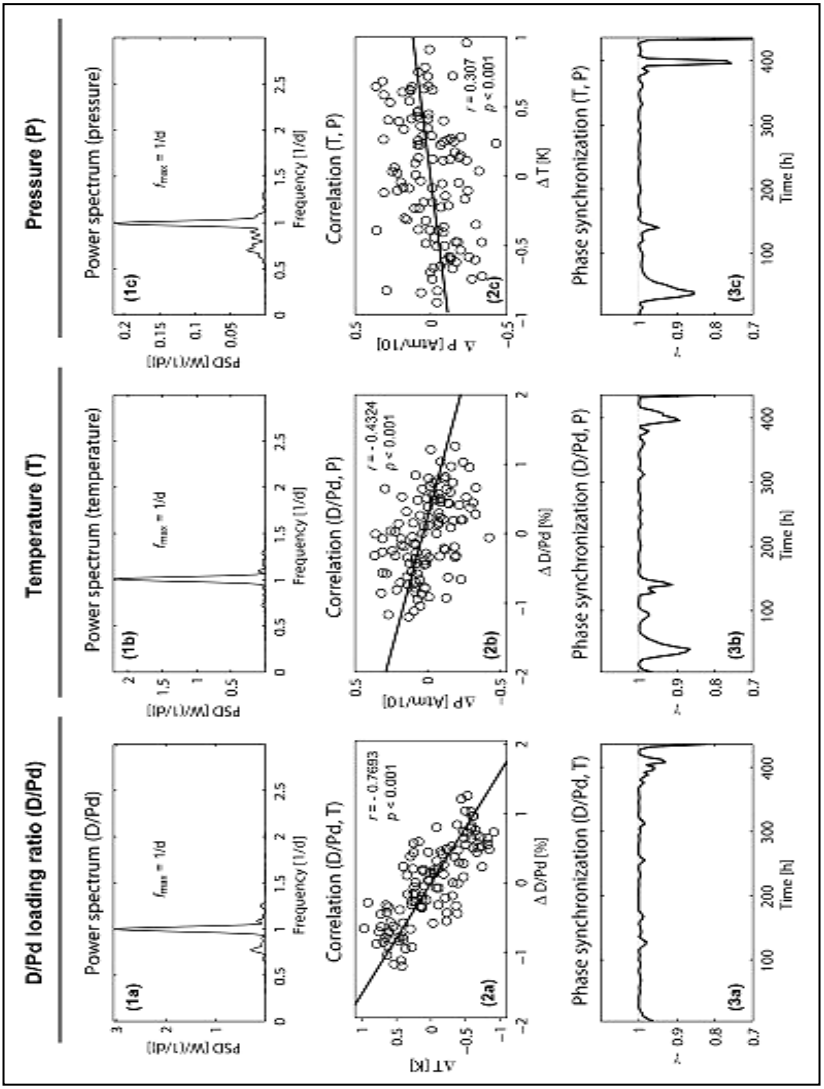

Examination of Errors That Occur When Using a Gas-filled Calorimeter

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Measurement of a reaction between D2 gas and a material using a calorimeter that is calibrated using H2 will show erroneous excess power production at temperatures above ambient if all energy present in the calorimeter is not totally measured, a requirement very difficult to accomplish. This insidious error has been explored using a stable Seebeck calorimeter.

Exposure of certain powders to D2 gas has been proposed to generate energy by a novel nuclear process. Verification of this claim requires use of an accurate calorimeter, a method to determine how much gas reacts with the sample, and a correlation between energy production and helium increase in the D2 gas. Such a system has been constructed and will be described in other papers. This paper addresses an important source of error this study has revealed. A useful calorimeter must meet several requirements including:

1. Be calibrated over a range of power and sample temperature;
2. Be stable over a long time;
3. Have applied electric energy used for calibration released near where the anomalous heat is generated so as to avoid errors that temperature gradients would generate:
4. Have a minimum energy loss or gain from the sample that bypasses detection.

The effect of #4 when using a conventional calibration based on H2 is explored in this paper. This is a major source of error in such measurements and can appear to indicate stable excess energy when the behavior of D2 is referenced to H2 even though no excess heat is actually produced. This error is universal to all types of calorimeters used in this manner because it is caused by the difference in thermal conductivity between D2 and H2.

Cold Nuclear Fusion in the Earth's Crust

Genadi Tarasenko

Caspian State University of Technology and Engineering named after Sh. Esenov, Kazakhstan

Subduction regime formation of oil is associated with the absorption of the oceanic crust into the mantle at a depth of more than 1000 km. At this depth, the temperature should not exceed 1000 C, at which organic matter preserved in rocks, will burn. But oil, on palynological analysis, the dispute remains and pollen (Medvedeva, Vinogradova, 1977) which burns at temperatures up to 600 C. Experiments to obtain oil, conducted at high temperatures (pyrolysis) does not result in natural oil, but to obtain oil by electric discharge in a solution of water with soda ash had led to oil, coal and diamond chips. Here, obviously the process of cold nuclear fusion, which proves the occurrence of such processes in the crust. Further studies should confirm the CNS in the earth's crust.

Initiation of The Cold Fusion Reactions by Air Components

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The approach to cold fusion phenomenon based on interaction between deuterium and the components of air in titanium is considered.

Experimental results which point at release of excess heat and neutrons are shown. On the basis of these results the nuclear fusion method and the device for its realization are patented. The application of this nuclear fusion method for nuclear waste transmutation, in particular caesium-137, is considered. On the basis of the calculations given conclusion about applicability of the method is made. According to the experimental data, saturation of titanium with deuterium+air mix results in temperature increase of the titanium deuteride sample by 45°., in comparison with saturation of the same sample with pure deuterium. The calculation of excessive heat emission based on these results is given. The conditions necessary for the cold fusion reactions to occur are formulated.

Flow Calorimetric Measurements of Interaction of H_2, D_2, He with Nanocoated Wires of Ni and Pd-Alloy at Temperatures upto 850°C

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In the framework of experiments, performed at National Institute of Nuclear Physics (Frascati National Laboratories), on the field of Condensed Matter Nuclear Science, we concentrated, from over three years, on methods aimed to generate anomalous excess heat at temperatures (T) well over that allowed by not-pressurised traditional electrolytic environments (by light or heavy water; T<100 ^{o}C). The aim was to explore the possibility to develop a device allowable to generate heat at temperatures larger than 300 ^{o}C, i.e. in regions were the maximum (Carnot's law limit) efficiency, from the point of view of (ideal) conversion from temperature to mechanical work, is of some practical interest.

The experiments were made using pressurised gas environments (typically at pressures<10Atm) and long (50-100 cm) and thin (50-100 лm dia) wires.

The material of wires, up to now, were Palladium (Pd), Nickel (Ni) and Platinum (Pt), the last used as "conservative reference". The, potentially active, wires (i.e. Pd, Pt) were coated by a thin multi layer of several elements: the aim is to improve the absorption of the specific gas adopted, Deuterium (D_2) and/or Hydrogen (H_2), by the bulk of the Pd or Ni. In other words, thanks to the intrinsic nanometric dimensions of the material of the nanocoating, they behave like "catalyser".

The materials of the nanocoating are made of two main types, added sequentially several times over each other (by simple, but time consuming, physical-chemical procedures): the first is pure Pd at nanometric sizes; the second is a proper mixture of several elements, each with a specific function, at nanometric sizes (5-20лm). Since April 2010 the materials of the mixture were, among others, B, Sr, Ba, Th.

Each wire is inserted inside an, high temperature resistant, electrically insulating thin (internal Ø= 1-2mm) sheath. At the beginning of the exper -imentation (2008), because the maximum temperature was <550 ^{o}C, we used glassy sheaths; later (2009->2010), because of use of higher temperatures, we moved to quartz (T<900^{o}C); recently (since June 2010) we are using Alumina (Al_2O_3) compounds (T<1200^{o}C).

Both wires, (i.e. one "active" Pd or Ni; second "inert" Pt) together with a third Pt wire used as extended thermometer, were braided over each other and put inside another glassy sheath into which is inserted also a conventional thermocouple. All the wires were rolled by a flexible mantle of thermal insulating material and put inside a gas tight reactor. The procedure of measurements, in principle, is quite simple, and was based on the recording of temperatures (by high accuracy type K thermocouple when the electric power was applied to inert (Pt) or active material (Pd, Ni), using a possibly active gas (D_2, H_2). The same measurements were also performed using inert gases (He, Ar, their mixtures). As a consequence, the anomalous excess heat, if any, is just the difference in temperatures when the power is applied to active or inert wire. The cycles of measurement were repeated several times, first to active and just after that to inert material, changing the amount of input power (e.g. 10, 20,…, 100 W). Such procedure is the isoperibolic method. Main advantage is the high speed of measurements (one every 20-30 m) the drawback is the fact that the temperatures depend on the thermal conductivity of gases used, so, several calibrations are needed changing the gas composition. For such reason, recently (June 2010) we moved to the standard flow calorimetry measurements. The measurement time increased to 3-4 hours, as expected: they were too long for

our explorative studies purposes. Starting from middle of September we radically modified the calorimeter so that the

time constant of the system was reduced to about 10 minutes using H_2, He, or D_2 gas. Obviously it increased in specific test, using Ar, to about 25 minutes.

About experimental results, the best value obtained, up to now, with Pd-D_2 was about 5 W at 550 ^oC, equivalent to a power density of about 400W/g Pd (presented at ICCF14, ICCF15, 239thACS meeting). In respect to the Ni-H_2–Ar system (with some previous D_2 perhaps still kept in the lattice), the best result was over 26 W at 850 ^oC, equivalent to a power density of 1800W/g of Ni (9th Workshop "Asti Series", Siena-Italy, Sept. 2010). All such results were obtained by fast isoperibolic measurements and procedures.

At the moment, we are finishing a new experiment (Ni-H_2, D_2) aimed to identify the possible transmutation of specific elements (by ICP-MS and, if possible, PIXE at Kobe University). Because of this another element was added to the previous composition, with a view to detect transmutations.

EL-01

The Theoretical Basis of SuperWaving LENR

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Energetics Technologies has contributed some of the most impressive results of excess heat production in the emerging field of Low Energy Nuclear Reactions (LENR). Essential details of these results have been reproduced successfully and independently, both at SRI in California and ENEA Frascati. The common denominator in producing and reproducing these results is the use of a novel current driving function formed as a self-similar pattern of waves having fractal-like character. This choice emerged from Dr. Dardik's study of the thermodynamics of energy metabolism in biological systems. Called "*SuperWaves*", this wave pattern appears to have profound implications in both living and non-living systems. In the latter it is responsible for the dynamics of motion, density and excess heat production as well as several (perhaps many) other important physical processes.

EL-02

The Evidence for the Fleischmann-Pons Effect

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At ICCF-14 we authors [1] presented results of applying a probabilistic model (a Bayesian network) to a subset of the published papers on the Fleischmann–Pons (FP) Effect in the database compiled by D. Cravens and D. Letts [2]. Those authors had analyzed a substantial part of the literature and identified four criteria for what constitutes a "proper" FP experiment; they stated that experiments that meet all four criteria are likely to produce excess heat, while those that do not are likely to fail. For a small subset of the papers (eight) the model gave a likelihood ratio of about 10 to 1 in favor of the FP Effect, with a generally upward trend as more papers were added.

Bayesian networks are graphical models through which Bayesian reasoning can be applied to sets of variables with complex interrelations; they are rooted in methods of scientific inference [3] dating back to Laplace's use of probability in celestial mechanics. It is suggested that they may usefully be applied not only to the FP Effect but to other vexatious scientific questions such as the global climate-change debate and conundrums like those surrounding dark energy and dark matter [4].

The work presented in this paper addresses two specific issues that were left unresolved at the time of ICCF-14 [1]. (1) The Bayesian network did not address the effects of publication bias—a tendency of researchers or editors to publish positive results in preference to negative (or vice versa). This important question is here given a quantitative treatment. (2) Software limitations had prevented handling more than a handful of papers at a time. These limitations have been circumvented, permitting essentially the entire Cravens-Letts database to be treated.

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Stimulation of PdD_x Wires at Cryogenic Temperatures

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Several groups [1,2] have reported heat and nuclear products production in thin PdD_x materials stimulated by different forms of electro-diffusion. We have extrapolated this technology to the electrical heating of thin PdD_x wires, which resulted in destructive high-speed melting, *i.e.* "exploding wires" (a technology that has been used to form extremely fine metal particles). Celani *et al* [3,4] have reported the electro chemical loading of thin Pd wires to approximately 1:1 and the electrochemical sealing of their surface. We have extended this technique to PdD_x where $x > 0.95$ and immersed these sealed wires in a liquid nitrogen (LN) calorimeter and analyzed them for anomalous effects. Celani *et al* also [5] reported using pulsed microsecond electrolysis to induce excess power.

We have tested the hypothesis that electrically exploding highly D-loaded Pd wires immersed in LN should release the deuterium and cause the evolution of gaseous N_2 equal to the electrical energy passed through the wire due to the enthalpy of vaporization of LN. Any excess heat generated during this stimulation is measured by the calibrated LN calorimeter as increased N_2 flow.

The cryogenic calorimeter comprises a well-insulated stainless steel (SS) Dewar flask, into which the sealed loaded wire is placed and connected to two large current electrodes. A pulse of current is passed through the wire, while the current, voltage and N_2 off-gas flow rate is measured with 100 μs resolution.

We will discuss the design, operation, sensitivity, and calibration of the calorimeter. We will also report the calorimetric results and the analysis of the off -gases for excess He and non-natural isotopic He ratios.

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Magnetic Field Triggering of Excess Power in Deuterated Palladium

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A brief summary of a series of experiments is presented, involving the effects of an external magnetic field on excess power (XP). The experiments show a similar pattern for bulk palladium (Pd) and for co-deposited Pd. The effect was first observed under very poor calorimetric conditions but the effect persisted even when tested with a good quality Seebeck calorimeter many years later. It was observed that rotating the cathode 90 degrees in a magnetic field of ~ 500 gauss in D_2O increased XP ~ 100% and rotating the cathode under the same conditions in H_2O had no lasting effect. Although the effect was not expected, it may have a logical and plausible theoretical explanation, based on the Ion Band State Theory (IBST) of low energy nuclear reactions (LENR) [**1**]. The connection to the IBST is discussed in detail. Construction and calibration of the Seebeck calorimeter is also discussed.

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Electrochemistry and Calorimetry of Ruthenium Co-Deposition

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Previous co-deposition calorimetric experiments have focused solely on Pd/D systems.[1] However, if the anomalous excess power is due to near surface effects or vacancies, then other metals may also be active in co-deposition experiments. Ruthenium was selected because this metal gives large electrochemical capacitance effects that may involve hydrogen ion absorption into the metal as well as adsorption at the surface.

The electrochemical co-deposition of ruthenium proved challenging due to the numerous possible oxidation states of this metal. Ruthenium (III) nitrosylnitrate, $Ru(NO)(NO_3)_3$, was selected for this study in the 0.15 M NH_4Cl+0.30 M NH_4OH/H_2O electrolyte. The ruthenium salt (0.025 M) readily dissolved to give a dark reddish solution with pH=2.53 prior to the addition of NH_4OH. This initial solution gave no sign of any displacement reaction with copper, silver, or nickel metals. The addition of the NH_4OH gave no precipitate and no color change despite the higher pH=9.67. Co-deposition at constant currents of 6, 10, 20 and 100 mA was tried using a copper cathode but the solution remained very dark in color. Finally, a current of 400 mA was tested, and the solution became completely clear overnight with a black deposit of ruthenium metal covering the copper cathode. The cyclic voltammetric study of this ruthenium cathode gave a completely tilted and collapsed trace that approaches Ohm's Law behavior as previously observed for palladium deposition.[2] This indicates a very large electrode capacitance (>1-2 Farads) as well a very large electrode surface area.[2] The persistence of the intense red color of the solution and the difficulty in obtaining ruthenium deposition suggest the formation of Ruthenium Red, a complex ammoniated ruthenium oxychloride inorganic dye.

Calorimetry was commenced following the ruthenium deposition. Extensive calorimetric studies using a constant current of 300 mA produced no excess power effects for this H_2O solution. This proves that there are no chemical or shuttle reaction effects for this system other than the normal H_2O electrolysis. No chlorine evolution was detected in these studies. Several additions of make-up D_2O were made that gave up to 30% by volume of D_2O. In mixed H_2O + D_2O systems, there is a possibility of H + D fusion reaction to form helium-3. However, our experiments produced no excess power for the deposited ruthenium cathode even for D_2O additions. A key experiment in progress is the calorimetric study of ruthenium deposition in pure D_2O.

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Excess Heat Power Registration In Experiments With High Voltage Electrolysis Cell

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The paper presents data resulting from investigation of Excess Heat power production in experiments with high voltage electrolysis cell (HVEC). D_2 loaded Pd cathode samples in Glow Discharge and light water were used in experiments. The cathodes used in the experiments were made of Pd foil, Pd coated Au, Pd coated Re and solid – state nanostructured Pd. The Glow Discharge was fed by the pulse-periodic power supply with the voltage 500 –3500 V and current meaning ranging 30 – 100 mA. The high voltage electrolysis cell was fed by the pulse-periodic power supply with the voltage 800 –2500 V and current meaning ranging 300 – 800 mA. The registered meanings of Excess Heat power obtained in the experiments amounted to 120 – 170 W with Heat Efficiency (the ratio between output heat power and the input electrical power) 200 – 340 % in HVEC experiments.

These total experimental results allow us to propose a Low Energy Nuclear Reactions phenomenological model based on interaction of electric discharge with the condensed matter (cathode system).

Progress of Reproduction of Excess Heat in $Pd|D_2O+D_2SO_4$ Electrolytic Cells

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Reproducibility of excess heat in Pd/D_2O electrolytic cells has been focused in our group for some years [1–4]. It was found that excess heats occur instantly after electrolyzing for a few hours rather than several days under proper procedures. The most important factors are two points: (1) Temperature increment in the beginning of electrolysis should be adequately high [2]; (2) Pretreatment of palladium cathode by electrolysis in open systems at high temperature is necessary [4]. Recently, it was found that an additive also is very important as observed using isoperibolic calorimetry [5]. Experimental details will be reported in the conference.

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The Observation of Abnormal Phenomena in a Pt(H)/ K_2CO_3/Pd System during its Electrolysis and Triggered by an Ultrasonic Wave Generator

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According to the previous work [1,2], some abnormal effects were expected to occur in Pt(H)/ K_2CO_3/Pd electrolysis system. Compared with the results from Pt(H)/ Na_2CO_3/Pd system, excess heat power of 0.178 W was detected in the process of electrolyzing K_2CO_3 solution in Pt(H)/ K_2CO_3/Pd system by investigating the variation of heat coefficient (k=$\Delta T/\Delta P$(℃/W)) in each system. New calcium ions might be formed in K_2CO_3 electrolyzing on the basis of spectrophotometer results by studying the concentration changes of calcium ions both in Na_2CO_3 and in K_2CO_3 solutions before and after the electrolysis. When these two systems were irradiated by an ultrasonic wave, there occurred cavitations' effect of hydrogen nucleus and then resulted in a decrease of solution temperature during the electrolysis process. And there was no obvious increase of new calcium ions when the ultrasonic wave was applied into them. The excess heat might come from the reaction:

$$K + P \rightarrow Ca^{2+} + 8.33MeV, \quad K + P \rightarrow Ca^{2+} + 10.22MeV$$ **[3]**

And the effect on excess heat by ultrasonic wave irritation was negative in these systems.

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Calorimetric & Nuclear Phenomena in Anode Plasma Electrolysis

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It was continued the investigation of (plasma) electrolysis with anode gas discharge. Voltage was (200-700)V. Current amplitude was (1-10)A. The electrolyte composition was (5-10)M NaOH in normal water. Nickel foil (0,1 x 50 x 100 mm^3) was used for cathode & Tungsten rod (6mm dia) was used for anode. For received results there were used following diagnostic methods:

1) Thermocouple calorimetry (sensitivity ~ 0.5°C), of different samples outside of electrolytic cell & 2-d water cooling circuit;

2) Tritium scintillation diagnostic in electrolyte (sensitivity ~ 0.1 Bq/ml);

3) Erzions flux generation with help of radiometer "Kran" (sensitivity ~ 2 counts/cm^2s) and usual & special dosimeters;

4) Photo emulsion & PSSD tracks diagnostic. Received results of regular reproducibility of excess heat, dosimeter & radiometer counts, special tracks observation and tritium generation are discussed.

Protocol for a Silicate-based LENR Using Electrodes of Various Metals

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We have developed protocol consisting of applying concurrent electronic and photonic stimuli to a cell with two or more electrodes at or near the boiling point of the liquid. The liquid in the cell is a solution including a silicate, a lithium salt, and, optionally, a surfactant. The electronic stimuli are RF signals and, optionally, a direct current. White LEDs provide the photonic stimuli. The protocol generates an exothermic reaction.

The silicate is an essential component of the reaction. We have successfully used anionic silica hydride, lithium silicate, and sodium silicate.

Of particular significance is that we have been able to generate temperature transients with palladium and metals other than palladium. We have also used silver, gold, and platinum electrodes, although palladium works the best

After the cell reaches the boiling point of the liquid, the applied stimuli add less than 100 mW of incremental power to initiate the reaction. The reaction has a gestation period varying from two to four hours.

We believe the exothermic reaction generated is nuclear in nature. The evidence supporting that statement includes these facts:

- Numerous data logs show brief, intense temperature transients during which the temperature of the liquid rises as much as 3°C in less than one minute.
- Scanning electron microscope (SEM) photos show evidence that palladium electrodes have surpassed their boiling point in microscopic regions during the experiments.
- Other SEM photos show large areas where electrodes have spalled during experiments.

- Electron diffraction scattering (EDS) analyses show strong evidence of transmutation of several elements in the reaction cell, specifically including the transmutation of palladium to silver.
- Auger analysis of one experiment also shows evidence of transmutation of the elements in the reaction cell.

We are prepared to show data logs of the temperature transients and SEM photos of the electrodes after treatment by the protocol.

Metallurgy and Calorimetry of Pd-B and Pd-Ce-B Materials

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Two palladium alloys, Pd-B and Pd-Ce-B, with low boron content were prepared at the Naval Research Laboratory (NRL) and then investigated for excess enthalpy production using two identical Fleischmann-Pons Dewar calorimetric cells. The Pd-B alloy produced significant excess enthalpy in contrast to no measurable excess enthalpy for the Pd-Ce-B material. These two materials were prepared using an arc melter with a water cooled copper hearth. Low boron contents (<0.75 weight percent) were used to keep within the miscibility gap. Processing of the electrodes introduced small amounts of copper (<26 ppm), tungsten (<2.2 ppm) and platinum (<47 ppm). The samples were annealed for two hours at 650 °C resulting in an average grain size of 90 μm for the Pd-B material.

The most unusual feature for the Pd-B electrode was the observation of excess power and positive feedback at a very early stage of the experiment (Day 3) at a low current density (48 mA/cm^2) and at a low cell temperature (29 °C).[1] This Pd-B experiment ran 68 days with excess power production often exceeding 400 mW. The cell was driven to boiling on Day 68 with the excess power exceeding 9 watts. There was a marked increase in the rate of excess enthalpy generation at temperatures approaching the boiling point that could be due to non-uniform charging of the Pd-B cathode. The investigation of "Heat-after-Death" in this experiment demonstrated that the rates of excess enthalpy generation before and after the cell boiled dry are probably identical. Such an identity would be expected if the excess enthalpy generation takes place in the bulk of the electrode. [1] Two U.S. patents have been awarded for the Pd-B excess enthalpy generation.[2,3].

The radiative heat transfer coefficient was evaluated to be k_R=0.85065x10^{-9} WK^{-4} for the Dewar cell used for the Pd-B experiment.[1] By assuming no excess power for the Pd-Ce-B experiment,[4] the lower-bound radiative heat transfer coefficient is k_R = 0.85118 ± 0.00790 x 10^{-9}WK^{-4}. This is remarkably good agreement for these two Dewar calorimetric cells. It was estimated that there was no excess power for the Pd-Ce-B cathode within a mean error range of ±0.8% of the input power. [4]

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Investigations of Possible Shuttle Reactions in Co-Deposition Systems

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Anomalous effects for Pd/D co-deposition were first reported by Szpak and Mosier-Boss using the $PdCl_2$ + $LiCl/D_2O$ system.[1] More reproducible calorimetric experiments have used the $PdCl_2$ +ND_4Cl + ND_4OD / D_2O co-deposition system based on commercial electroplating baths for palladium.[2,3] However, the Naval Research Laboratory (NRL) has proposed that the measured excess power effect may be due to shuttle reactions (a form of recombination) involving nitrates or chlorates that may be produced in this deuterated ammonium chloride (ND_4Cl) system.

Various electrochemical studies were employed to test for possible shuttle reactions involving nitrates, nitrites, and chlorates. There was no experimental evidence obtained for any shuttle reactions in these experiments. For example, cyclic voltammetric studies for the NH_4Cl + $NaNO_3$ + $NaClO_3/H_2O$ system revealed no significant reactions other than the H_2O electrolysis. Similar results were obtained using galvanostatic power pulse studies. Furthermore, these experiments proved that electrode reactions of nitrates or chlorates could not even support constant currents of 0.001 A/cm^2. Electrochemical impedance spectroscopy (EIS) experiments showed very slow kinetics for any electrochemical reactions involving chlorates or nitrates.

Electrode reactions simply cannot occur faster than the mass transport or diffusion process that supplies the reactants to the electrode surface. The equation for the mass transport process yields a limiting current density of only about 0.001 A/cm^2 for the shuttle reactions of nitrates or chlorates in co-deposition systems. For H_2O electrolysis, in contrast, the limiting current calculates to be more than 4 A/cm^2. Further evidence against shuttle reactions in co-deposition systems is that the

experimental consumption of D_2O exceeds the theoretical amounts even when significant excess power is measured. Additionally, the large extended excess power effects observed in D_2O are not present in H_2O. Finally, calorimetric experiments for both the KNO_3 and $NaClO_3$ electrolytes showed no excess power effects.[3] In conclusion, this deuterated ammonium chloride co-deposition system has previously produced positive feedback and "heat-after-death" effects similar to those reported for other Pd/D systems.[2]

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New Analysis of MIT Calorimetric Errors

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The MIT calorimetry published in 1990 [1] had a major impact in convincing scientists that the anomalous excess enthalpy reported by Fleischmann and Pons in Pd/D systems was due to various errors. Nevertheless, the MIT heat conduction calorimetry has a stated sensitivity of 40 mW while the Fleischmann-Pons Dewar calorimetry achieved a sensitivity of 0.1 mW. [2] Additional information about the MIT calorimetry [3] has allowed a more detailed analysis. The major new finding is that the walls of the MIT calorimetric cell were so well insulated with glass wool (2.55 cm in thickness) that the major heat transport pathway was out of the cell top rather than from the cell into the constant temperature water bath. The walls of any heat conduction calorimetric cell could be insulated to the point that almost all heat flow would be out of the cell top.

From the published MIT date [1,3], an unusually small conductive cell constant of k_C=0.088 W/K is calculated that reflects the thick cell insulation. For the typical MIT total input power of 1.76 W, only 0.68 W flows across the thick insulation of the water bath. It is calculated that 1.02 W flows through the cell top and 0.06 W flows through the cell bottom. The heat flow pathways, therefore, are 39% through the cell wall, 3% through the cell bottom, and 58% through the cell top. The large heat flow through the top of the MIT calorimeter accounts for their reports of large electrolyte level effects and marked effects of the room temperature variations. [1,3]

Analysis of the Fleischmann-Pons Dewar cell shows that under conditions similar to the MIT experiments (T_{cell}=46.0 °C, T_{bath}=26.0 °C), almost all of the heat flow would be from the Dewar calorimetric cell to the constant temperature bath as

desired. Furthermore, the sensitivity of the Fleischmann temperature measurements were 0.001°C versus a sensitivity of only 0.1°C for the MIT calorimetric cell. The evaluation of the calorimetric equations and data analysis methods leads to the clear conclusion that the Fleischmann-Pons calorimetry was far superior to that of MIT. Even today, no electrochemical calorimeter exceeds the accuracy and sensitivity reported by Fleischmann. [2]

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Production of Neutron-rich Bi Isotopes and Hypothesis About Formation and Decay of the Long-living Nuclear Molecules.

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In experiments on electric field influence on solutions of salts of bismuth generation of isotopes of bismuth 210Bi, 212Bi, 214Bi and an isomer 212Bi with energy of excitation 250 κeV was found out. Generation of isotopes is accompanied by a departure from the sample of streams of macroscopical particles (~ 5 microns) [1].

Based on the analysis of experimental data obtained in the experiment with the salts of bismuth, attempts to prove the existence of long-lived nuclear molecules are discussed. It seems that the object consisting of nuclei is associated with magnetic and nuclear forces [2].

Properties of long-lived nuclear molecules are discussed. The other experiments are analyzed [3].

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Statistical Analysis of Diurnal Variations in an LENR Experiment

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Diurnal variations were observed in a high pressure low energy nuclear reaction (LENR) experiment at the Hokkaido University [1]. The D/Pd loading ratio as well as temperature and pressure inside the reaction chamber were recorded for more than 800 hours. 440 hours of these data (while the signals were stationary and exhibit the greatest fluctuations) were analyzed statistically by filtering, decomposition into Intrinsic Mode Functions (IMFs) using the Ensemble Empirical Mode Decomposition (EEMD) method [2], statistical testing of the IMFs using the approach of Wu and Huang [3], determination of temporal power spectra, and computation of correlations and phase synchronizations between the D/Pd loading ratio, temperature and pressure. Some of the results are presented in the figure given in the next page.

The conclusions from this analysis are: (1) There is a diurnal oscillation present in the D/Pd, T and P signals, (2) The oscillation of D/Pd is inversely related to the oscillations in the T and P time series, (3) D/Pd and T, and D/Pd and P, are significantly correlated ($r_{D/Pd,T} = 0.77$, $r_{D/Pd,P} = -0.43$, $p < 0.001$), where p is the significance level, and (4) The oscillations of all three signals are in phase over the whole selected period of time (320-760 hours) when the D/Pd loading ratio is > 80 %.

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Modeling Excess Heat in the Fleischmann-Pons Experiment

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Excess heat in the Fleischmann-Pons experiment presents a challenge for theorists for a variety of reasons. Perhaps the biggest is why it happens at all, as well as how it works. We think the energy is of nuclear origin, because there is so much of it, because there is no sign of commensurate chemical reaction products, and because He^4 is seen in amounts commensurate with the energy. In nuclear physics, when energy is produced in a nuclear reaction, that energy appears as kinetic energy of energetic nuclear particles. However, in the Fleischmann-Pons experiment there is no evidence for commensurate energetic products. Hence, whatever process is responsible for the energy, it is one that has not been seen previously. It must be a new physical effect.

We have computed yields for some reactions that give rise to secondary penetrating radiation assuming that alpha particles are present in amounts commensurate with the energy. We find that the yield for secondary neutron emission is very high, so that if He^4 was initially created as a fast alpha, then the average energy would have to be below 20 keV to be consistent with the upper limits on neutron emission observed during heat bursts in the literature. As a consequence of this, the majority of reaction schemes that have been proposed over the years can be ruled out as inconsistent with experiment, since most assume that the reaction energy is expressed in energetic radiation. Our result basically says that it is very difficult to "hide" energetic particles, and that if they were there we would know already.

We have pursued models in which a very large energy quantum is fractionated into a very large number of very small quanta. We have recently obtained numerical and analytical results for a version of the lossy spin-boson model (which is particularly good at splitting a large quantum into many small quanta) where we have obtained reasonably efficient coherent energy transfer

when the fractionation involves more than 10^6 quanta, as required for the Fleischmann-Pons excess heat effect.

Based on these results, we can analyze models that seem to be relevant for excess heat production. In these models, molecular D_2 inside the lattice undergoes a transition to He^4, with the energy transferred to other states that then fractionate it. In these models the down-converted energy ends up in condensed matter modes, such as optical phonon modes (as in the 2-laser experiment), hybrid optical-plasmon modes (as in 1-laser experiments), and also THz acoustical phonon modes. These modes thermalize quickly, and shows up as thermal power. These models appear to us to be closely related to many experimental results in the field.

Roles of Crystal Size, Electromagnetic Fields and Deuterium Flux in Triggering Excess Power in PdD

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In the Ion Band State Theory (IBST) of low energy nuclear reactions[1], the Fleischmann-Pons excess heat effect results from a form of deuteron nuclear fusion reaction, without high-energy particle emission, that can potentially be initiated when the interacting *d*'s and the He^4 product occupy wave-like, ion band states (IBS's), which are similar to the kinds of wave-like (energy band) states that electrons occupy in ordinary metals. The theory is based on a generalization of conventional (electron) energy band theory. By using this generalization, it is possible to identify coherent forms of interaction between *d's* that are responsible for the nuclear reaction. These occur when collisions between *d's* actually become stifled as a result of periodic order. This idea has important consequences because in order to preserve periodic order, the associated processes can trigger the nuclear reaction only through particular effects that involve creating and altering particular forms of current (involving *d's* in ionic form) in a very specific manner that can be strongly affected by crystal size and/or the presence of an externally applied electromagnetic field.

As a consequence, in the simplest situation, it is possible to understand how either through an internally generated electrical () field that is induced as a result of the process of loading deuterium (D) atoms into Pd (as well as by co-depositing D and Pd onto a substrate) or by externally applying an -field, it is possible to trigger nuclear reactions. The associated arguments show that in larger crystals, in the most coherent limit, the time for any nuclear reaction to occur can increase dramatically. Specifically, as the characteristic dimension of a crystal increases by a factor of 10, the time delay before a nuclear reaction is

triggered increases by a factor of 1000. The theory suggests that the smallest crystal that can sustain a fusion reaction through the most coherent process, which has a characteristic dimension *a* ~4.5 nm, requires a triggering time ~ 1 ms; while in a crystal that has a value of *a*m that is 1000 times greater, is on the order of a billion times larger (~18 days). The theory also suggests that optimal triggering occurs when the net flux of *d's* that occupy IBS's into and away from the crystal vanishes and when that is created from each nuclear reaction is expelled from the bulk region in an ionic, IBS form, through currents that obey the conventional semi-classical transport equations that describe electron currents in periodic solids. These results can be related to the flux requirement (in which excess power becomes proportional to deuterium flux) that McKubre et al[2] have identified as being important in triggering excess heat.

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Simulation of Palladium Fission Products Using the FCC Lattice Model

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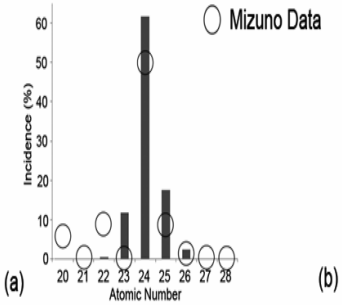
The approximate nucleon build-up procedure for all nuclei is known from the independent-particle model (IPM) and implies specific 3D structures for any isotope in the nuclear lattice model [1, 2]. Using those lattice structures, the favorable modes of fission have been simulated and the fission fragments compared with (i) the known fission fragments from Uranium [2], and (ii) the transmutation products from Palladium, as reported by Mizuno [3]. Here, we show that the main transmutation products in Mizuno-style LENR studies are produced in the lattice simulation of Pd+D fission.

We have previously reported that a lattice model of nuclear structure [1, 2] – first stated by Wigner in 1937 and subsequently shown to be identical to the IPM – predicts the ***asymmetrical*** fission fragments produced by the thermal fission of the actinides ***without*** using any "adjustable parameters" to produce the asymmetry. The basic finding is a consequence of the fact that scission along oblique planes of the lattice structures for the actinide nuclei requires breaking ***fewer*** nearest-neighbor nucleon-nucleon "bonds" than symmetrical slices through the same nuclei. Because of the large excess of neutrons that give the actinides an oblate shape, oblique slices through the lattice show a 3:2 mass ratio. That result can be easily verified using the *Nuclear Visualization Software* (www.res.kutc.kansai-u.ac.jp/~cook). The fission of Palladium can be simulated using the same software, and shows that the lattice structures for Palladium undergo approximately ***symmetrical*** fission. The figure below shows the results of a simulation of the fission of a compound nucleus (Pd+D) in

comparison with the Mizuno data [3]. By randomizing the location of all surface nucleons and selecting the most stable lattice structures, the majority of the fission fragments from the Palladium isotopes was Chromium.

The large excess of Chromium isotopes found experimentally was well-reproduced, although fragments with relatively large and small atomic numbers (12, 14, 16, 20, 29 and 30) were not found in the simulation. Large increases in Cr^{53} and Cr^{54} and a large decrease in Cr^{52} – relative to the natural abundances – were also predicted, as found in the Mizuno data (although not the increase in Cr^{50}).



(b)

	Cr^{50}	Cr^{52}	Cr^{53}	Cr^{54}
Natural abundance	4.3%	83.8%	9.5%	2.4%
After electrolysis (expt)	14.3%	50.9%	23.8%	10.9%
Simulation	0.0%	7.9%	76.8%	15.3%

Figure: (a) A comparison of simulation results and the data from Mizuno [3] (open circles). (b) A comparison of the changes in the natural abundances of the four main Chromium isotopes following electrolysis.

The nuclear lattice model does not require arbitrary adjustable parameters to explain the asymmetry of Uranium fission fragments [2]. The same lattice-scission technique also produces the approximately symmetrical pattern of experimentally-known nuclear "ash" found in LENR experiments. We conclude that the substructure provided by the nucleon lattice is a necessary addition to conventional nuclear theory. For explaining the heat production and radiation in LENR studies, nuclear structure theory is not important, but, for explaining the anomalous elements and isotope ratios in transmutation studies, nuclear structure becomes relevant. Without the use of ad hoc parameters, conventional models are ***incapable*** of explaining

the fission fragments of either Uranium or Palladium [2], but the lattice model can explain both the old transmutation data of the fission of Uranium and newer data on the low-energy transmutation of Palladium ***without*** the use of ad hoc model parameters.

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Quantum-Correlated Fluctuations, Enhanced Tunneling, and Low-Energy Nuclear Reactions in Condensed Matter (Alloys)

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In heavily (deuterated or hydrogenated) palladium, some of the crystalinity is lost. As a consequence, the localized phonon modes of the crystal/damaged-region interface have a much higher frequency than the host. These high-frequency modes create electrostatic fields that interact strongly with electrons of the local atoms. A resulting instantaneous potential inversion [1] leads to the formation of lochons (local charged bosons – electron pairs in the singlet state, perhaps isolated from the Pd d energy levels) and of an associated H^+ or D^+ ion (with its 2 electrons instantaneously isolated into the adjacent Pd d levels). The Coulomb repulsion between the nuclei of these polarized pairs is greatly reduced by strong screening from the lochons that can even generate an attractive potential in the form of a drag effect [2].

Furthermore, the mutual tunneling penetration probability of the Coulomb barrier is enormously enhanced by correlated fluctuations [3]. This arises from the generalized uncertainty relation, $\delta x\, \delta p_x \geq (n+1/2)\hbar/(1-r^2)^{0.5}$, where n = 0,1,2,3…, and where results from [3] and [4] are combined. The integer n values represent excitation phonon modes of the H or D sub-lattice and r is the correlation coefficient. Higher values of n and r, for a particle in a potential well, imply less localization and greater uncertainties in location (i.e., extending its probability distribution into the barrier). These periodic fluctuations into the barrier are an interference effect similar to that of beat frequencies.

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From the Naught Orbit to He^4 Ground State

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An electron pair (lochon) in a hydrogen naught orbit (n = 0) [1] has similarities to muonic hydrogen in that it has a small orbital radius that allows the protons in molecular hydrogen to be very much closer together than is possible in a normal molecule. There are also significant differences. However, since muon-catalyzed fusion [2] is an accepted phenomenon and Lattice-Assisted Nuclear Reaction is not, we will examine the similarities and differences in both mechanisms with the fusion of deuterons in mind. We start with Naudt's assumption [3] that the Klein-Gordan equation solution identifying a single deep orbit (that has here-to-for been ignored) is actually real. It is generally accepted that, at least for bosons such as the lochon, the Klein-Gordon equation holds. We then compare the creation model and characteristics of these naught orbits with those of the muonic orbits (both atomic and molecular).

The similarities lead both naught-orbit and muonic-orbit molecules to fusion. The differences lead the non-relativistic muon-induced fusion of deuterons to the fragmentation of an excited helium nucleus and the relativistic lochon-induced D-D fusion to an excited He^{4} state that is below the fragmentation levels [1]. The reason for this different response to the respective "tight" orbits will be described along with some of the consequences.

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Introduction to Pico-chemistry and Experimental Approach.

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Recently, sizeable energy productions were reported [1], which did not show the expected nuclear signatures [2]. To explain this anomaly, a scenario was proposed [3] and called pico-chemistry. This scenario is a 2 steps process that gives a convenient frame to understand most of the observations made in the field of co-called CF; LENR, LANR …

The first step of the process is the formation of a bound state between a metal and an hydrogen isotope. This step is essentially due to the electro-magnetic force and results in a compound where a shrunken hydrogen atom is bound to the nucleus of an atom, at picometer distance of it (hence the name). A guesstimated description of this bound state will be given.

The second step is a subsequent reaction between the virtual neutron state of the shrunken hydrogen atom and the nucleus of the host atom, resulting in various nuclear signatures (gamma emission, charged particles emission…) depending upon the host atom. These reactions do not contribute very much to the energy production, but have a clear nuclear signature.

Finally an experimental device will be presented to check this hypothesis and the first results will be disclosed.

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Localization Effects of Low-Energy Deuterons in a Lattice

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Reproducible results have indicated that transmutation reactions occur in deuterium-loaded palladium electrodes, leading to a large array of transmutation products and suggesting that a fission-like process is involved [1]. Close similarity has been reported with the distribution of the fission products of uranium, where the intermediate compound nucleus in the fission process is excited to energies in the MeV range. Thus, it has been postulated that an excitation of the intermediate compound nucleus may occur in LENR array experiments where a fission reaction via an excited nucleus appears to be involved. The question is how the multi-body reactions needed to form the compound fissioning nucleus can occur in a low-temperature solid. As transmutation array data accumulated, the reactions were associated with localized regions where condensed matter states, clusters of D, were postulated to have formed [2]. If the cluster volumetric density can be increased, a significant increase in the overall reaction rate in the electrode for developing a high-performance LENR cell should be possible.

If their interaction distance is around 2 pm, this solid-state plasma is reactive and competitive against thermal motion. The Coulomb screening effect [**3**] for the deuterons in highly loaded metals has been gaining more attention and its importance recognized. Recent measurements have confirmed anomalous screening in a variety of substrate metals. Therefore, deuterons can be viewed as moving as electrically neutral particles within the palladium.

g	g_o	$2g_o$	$3g_o$
(MeV)	0.079	0.3	2.13

Table: Energy transfer from localization effects by lattice Planes with $g=ng_o$ for particles of energy, E=1eV and $m=10^{-24}g$. Here $g_o=8.3\ 10^{10}\ cm^{-1}$

In this paper it is shown that, through an exact solution of the Schrodinger's equation assuming strong short range interactions in the absence of coulomb repulsion, strong localization effects can be obtained whenever particles interact with nuclei, if these are located on a lattice *and* if an ordered structure of nucleons exist [4] within nuclei themselves. The effect arises as a result of coherent scattering from all the nucleons. If ordering is absent, like in a liquid drop, the effect becomes vanishingly small. For a given lattice plane the wave function decays exponentially with distance from the plane with a rate given by the wave vector *g* of that plane. The effect is found for incoming low-energy particles, such that their de Broglie wavelength is larger than the nucleon separation, i.e. ~2 fm. It is found that the increased particle density corresponds to an energy transfer to nucleons in the MeV range, depending on the lattice planes, the interaction strength and the particle mass.

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Low Energy Sub-barrier Correlated Nuclear Fusion In Dynamical Systems

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Probability of nuclear reactions for charged particles at low energy is defined by the action of Coulomb barrier and is bounded by a very small probability of the tunnel effect $D = e^{-W(E)} << 1$. In the present work the universal mechanism of optimization of low energy nuclear reactions on the basis of correlated states of interacting particles is considered. This mechanism provides the great increase of barrier penetrability under critical conditions (very low energy, high barrier), where the effectiveness of "ordinary" tunneling effects (including resonant tunneling one) is negligibly small, and can be efficiently applied to different experiments.

We have considered preconditions and methods of formation of correlated coherent states of nuclei in the nuclear-synthesis systems [1]. The physical reason of the barrier transparency in correlated states increase is the following [1,2]. The presence of a partial correlation of different eigenstates forming the correlated superpositional state. Formation of such correlated state leads to the cophasing and the coherent summation of momentum fluctuations of the various eigenstates. It leads to increasing of momentum variance σ_p, kinetic energy variance $\sigma_T = \sigma_p / 2M$ and barrier transparency.

This effect is connected with the modified relation of uncertainty $\sigma_A \sigma_B \geq \hbar^2 / 2(1 - r_{AB}^2)$ for coherent correlated states [1,2]. Here $r_{AB} = \sigma_{AB} / \sqrt{\sigma_A \sigma_B}$ is the coefficient of correlation, which determines the cross correlation of A and B, $\sigma_{AB} = < \widehat{A}\widehat{B} + \widehat{B}\widehat{A} > / 2 - < A >< B >$ is the cross variance of

A and B, $|r_{AB}| \leq 1$. For uncorrelated states $\sigma_{AB} \equiv 0$ and $\sigma_A \sigma_B \geq \hbar^2 / 2$.

We have determined the form of optimal dependence of the correlation coefficient $r_{pq}(t)$ on time, at which the formation of a maximally correlated states of particles with $|r_{pq}| \mapsto 1$ and the attainment of the maximal variances $\sigma_q \to \infty$, $\sigma_p \to \infty$ are possible. The optimal regimes of asymptotic or periodic formation of completely correlated states of a particle with the giant increase of coordinate variance σ_q under the potential barrier and similar giant increase of both tunnel effect probability and nuclear reactions probability are determined.

It was shown for the first time that in real nuclear-physical systems very sharp grows (up to 10^{50} and more times!) of Coulomb barrier transparency $D(E) \to 1$ at very low energy with the increase of correlation coefficient $r_{pq}(t)$ is possible. Several successful low-energy fusion experiments (e.g.[3]) based on usage of correlated states of interacting particles are discussed.

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The Physical Reasons of Existence of Large-Size Neutron-Nucleus Molecules and Related Anomalies of Long-Distance Low Energy Fusion and Fission

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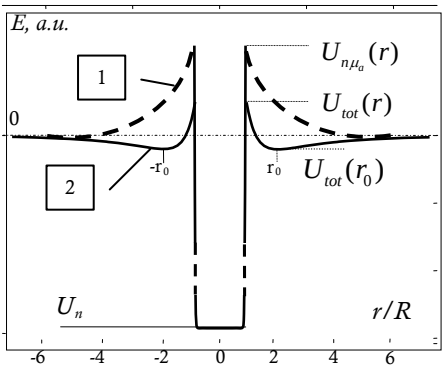
In the work the problem of existence, method of creation and possible applications of large-size neutron-nuclear molecules in low-energy nuclear reactions are considered. Features of electromagnetic interaction of thermal and slow neutrons with nuclei outside nucleus (at $r \geq R$) are examined. On the basis of the Dirac equation

$$\varepsilon\Psi = \left\{ c\begin{pmatrix} 0 & \hat{1} \\ \hat{1} & 0 \end{pmatrix}\vec{\sigma}\hat{\vec{p}} + \begin{pmatrix} \hat{1} & 0 \\ 0 & -\hat{1} \end{pmatrix}\left(m_n c^2 + \mu_a \vec{\sigma}\vec{H}(\vec{r})\right) + i\begin{pmatrix} 0 & -\hat{1} \\ \hat{1} & 0 \end{pmatrix}\mu_a \vec{\sigma}\vec{E}(\vec{r}) \right\}\Psi,\ \Psi = \begin{vmatrix} \varphi \\ \chi \end{vmatrix},\ \varphi = \begin{vmatrix} \psi_1 \\ \psi_2 \end{vmatrix}$$

analysis [1] it was shown that the process of neutron-nuclear interaction outside nucleus is described by Schrödinger wave equation

$$\left(-\frac{\hbar^2}{2m_n}\Delta + U_{n\mu_a} \pm U_{\mu_{A,Z}\mu_a}\right)\psi_{1,2} = E\psi_{1,2},\ E = \varepsilon - mc^2,\ U_{n\mu_a}(r \geq R) = \frac{\mu_a{}^2 Z^2 e^2}{2m_n c^2 r^4},\ U_{\mu_{A,Z}\mu_a}(r) = \mu_a H(r)$$

and is determined by the presence of ponderomotive non-linear potential barrier $U_{n\mu_a}(r \geq R)$, which is located outside of any nucleus (see graph 1 on Fig.).



For even-even nuclei the own magnetic field $\vec{H}(r) = 0$. The height of this barrier is $U_{n\mu_a}(R) = 110 eV$ for heavy even-even nuclei like U^{238} and 25...65 eV for even-odd nuclei like U^{235}, U^{233} and Pu^{241}. For light even-even nucleus d^2 the height of the barrier is 7 eV. The mechanism of formation of this barrier is the result of non-linear ponderomotive interaction of the neutron abnormal magnetic moment μ_a with the strong external electric field of a nucleus. The barrier penetrability for thermal reactor neutrons equals $D \approx 0.95...0.98$. For cold neutrons the barrier penetrability decreases greatly and for ultracold it becomes very small and $D \to 0$. It was shown for the first time [1] that at the unlimited decrease of neutron energy $E \to 0$ the full cross-section of reactions (with the participation of any nucleus and such neutrons) is negligibly small and $\sigma_{f(tot)} \sim v \to 0$. It makes impossible any reactions (both fusion and fission) between neutrons and nuclei at $E \to 0$! For even-odd and odd-odd nuclei $\vec{H}(r) \neq 0$. In the work the existence of separated neutron potential wells symmetrically located at $r_0 \approx (1.7-4.5)*10^{-12}\ cm \approx (1.3-5)*R$ from even-odd and odd-odd heavy nuclei is predicted (see graph 2 on Fig). Formation of this distant wells is the result of combined action of magnetic $U_{\mu_{A,Z}\mu_a}(r > R) = 2\mu_{A,Z}\mu_a / r^3$ and ponderomotive $U_{n\mu_a}(r \geq R)$ interactions of neutron magnetic moment with own electric and magnetic fields of nucleus. Depths of these wells are $U_{tot}(r_0) = 0.1...5$ eV for U^{235}, U^{233} and Pu^{241}.

The presence of such distant wells leads to the possibility of existence of virtual or quasi-stationary nuclear-neutron molecules. Such wells can be virtual traps for thermal and cold neutrons. They can stimulate long-distant fusion and fission reactions between distant nuclei at very low energy. The effect of neutron halo also may be connected with such virtual traps.

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Nuclear Exothermic Reactions in lattices Pd: A Theoretical Study of d-d Reaction

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During the past 15 years, indisputable experimental evidence has built up for low energy nuclear reaction phenomena (LERN) in specialized heavy hydrogen systems. We can say that a new possible way to obtain nuclear energy without waste is emerging. Nevertheless in spite of experimental contributions, the theoretical framework is not known. In this work we try to explain the deuteron-deuteron reactions within palladium lattice by means of the coherence theory of nuclear and condensed matter.

The coherence model of condensed matter affirms that within a deuteron-loaded palladium lattice there are three different plasmas: electrons, ions and deuterons plasma.

Then, according to the loading percentage $x=D/Pd$, the ions deuterium can take place on the octahedrical sites or in the tetrahedral in the (1,0,0)-plane. In the coherence theory it is called b-plasma the deuterons plasma in the octahedral site and g-plasma which in tetrahedral.

We propose a general model of effective local time-dependent deuteron-deuteron potential, that takes into account the electrons and ions plasma oscillations. The main features of this potential are extracted by means of many-body theory considering the interaction deuteron-phonon-deuteron. In fact the phonon exchange produces a attractive component between two deuteron within the D_2 molecular. This attractive force is able to reduce the inter-nuclear distance from about 0.7 Å to 0.16 Å. It means that the lattice strongly modifies the

nuclear environment with respect to free space. In this way according to deuterons energy, loading percentage and plasma frequency we are able to predict high o low tunneling probability. The fusion rates (sec^{-1}) computed vary from 10^{-70} to 10^{-17} and also a set of other mechanism, which could be enhanced these values, are proposed. In this way we hope that by means of this approach in the future will be possible to realize and control the nuclear exothermic reactions that take place in the condensed matter in order to obtain clean energy.

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Erziotriton & Cold Nuclear Transmutation Coursed by It

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In report on the RCCNT&BL-16 in framework of Erzion model (EM) it was proposed the hypothesis of possible existence of alone neutral Erzion atom (Erziotriton - $\{Э^-,H^3\}$), which has on its orbit super heavy hydrogen isotope – Triton. Bond energy of such Erziotriton is - ε~70 keV and size - R~8 fm. There it was shown for interpretation Baranov experimental results that in the reaction $Bi^{209} + \{Э^-,H^3\} = Bi^{212} + Э^0 + 7,6$ MeV the transmutation reaction of Bi^{209} to Bi^{212} is running. Here such class nuclear transmutation reactions are expanded on the light nuclei (C,N,O,…). It is presented unique opportunities of such nuclear reactions with production of some alpha particles of large energies and radiation of large neutron quantity in alone reaction, indications on which there were existed already rather long time in some experiments.

Compatibility of Ionic Crystal Lattice Assisted Nuclear Fusion and Thermonuclear Fusion

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The ionic crystal lattice assisted *p-p* nuclear fusion in a room temperature apparatus and thermonuclear fusion achieved at ultrahigh temperatures and pressures are compatible. It is possible to reach the latter process through the former one. On sodium metal dissolution in concentrated aqueous Epsom ($MgSO_4.7H_2O$) solution undergoing vortex rotation, the hydrogen ions (*protons*) generated due to Na-H_2O and Mg-H_2O reactions are trapped *in situ* in cavitation induced ionic nanocrystals and oscillatory reactions due to two strong mutually opposing forces – one is electrostatic repulsion between hydrogen nuclei leading to the break-up of these crystals on formation and the other is cavitation induced crystallization – could build up localized temperatures and pressures around the nanocrystals exponentially through repeated release of hydration energy to the point required to achieve nuclear fusion, i.e., plasma temperatures, all by the heat generated within the system. It is known that the temperature inside a cavitating bubble is only 5000 K only and hence its implosion cannot cause nuclear fusion by itself. Cavitation process is, however, invoked in our experiment for quite a different purpose i.e for the formation of micro/nano crystals. The nanocrystals of $MgSO_4$/ Na_2SO_4 act as precursors and help in localizing the hydrogen ions in the initial stages and the water surrounding them provide the medium for the generation and accumulation of hydration energy exponentially in and around these crystals until the runaway exothermic reactions lead to the release of *p-p* fusion energy outward in all directions which resulted in the vaporization of glass beaker along with its contents. Thus it is the exponential accumulation of hydration energy and not cavitation energy by itself which generates the input energy needed to create the proposed *p-p* fusion process. Cavitation merely facilitates this process. An application of Bernoulli's equation, however, indicate that cavitation is occurring in the aqueous Epsom solution not

because of stirring (pressure drop on rotation is too low for boiling to occur at RT or even up to 60^0C in this case) but due to the collapse of vapor bubbles generated as a result of the highly exothermic Na dissolution and distribution of these local boiling spots during stirring. After all, a fluid can vaporize when its pressure becomes too low, or its temperature too high.

Let us consider plasma physicists point of view that even at a temperature of 10^{10} K, it would take millions of years to produce the number of reactions required since it is a weak interaction and hence, *p-p* fusion can be ruled out as a mechanism. However, we could begin by getting a bound state via the strong interaction, and then a *p* would decay into $n + e^+ + \nu$ which is a weak interaction. But the latter is fast enough that the weak interaction would be irrelevant. Thus the *p-e-p* reaction in the sun has a low probability. But in LENR conditions, it should be very probable.

Hydrogen fusion in hot plasma condition through the reaction:

$$^1H_1 + {}^1H_1 \rightarrow {}^1D_2 + e+ + \nu \text{ (neutrino)} + \text{energy } (6.945 \times 10^7 \text{ kJ/gm})$$

is known to release positrons (e^+) which would very quickly encounter a free electrons (e^-) in the atmosphere and both particles annihilate, their mass energy appearing as two γ-ray photons of 0.51 MeV, each in 180^0 opposite direction. In the explosive experiment described above, the number of 0.51 MeV photons released in one direction would be about 0.24×10^{23} in a flash. However, only a low level of radiation exposure is anticipated due to annihilation radiation at the observer's position (3 m from the beaker which caused the explosion) following *p-p* nuclear fusion since we are not dealing with a point radiation source (which would give a high radiation level as indicated above) but with several (annihilation) sites of radiation source which are blown apart and hence will be situated all around and far away from the site which caused the explosion. But the presence of even a small amount of such radiations could be considered as signatures for the proposed fusion process.. Measurement of γ-radiation dose using passive dosimeters is also a viable choice to substantiate the proposed *p-p* nuclear fusion and are being planned.

Notwithstanding experimental confirmation of the reaction products, this is the first time a novel and viable concept capable of generating infinite energy without violating existing scientific laws is outlined.

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A Possible Explanation for 'How Coulomb's Repulsion is Overcome in Cold-Fusion'

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The primary objection, besides lack-of-reproducibility, was the 'absence of a good theory' behind cold-fusion [1-6]. Though a few theories were proposed, the main objection that 'how coulomb-repulsion between deuterium ions is overcome' was never clearly explained. In the present paper a novel theory in this regard is proposed which is based on a new found effect called 'Gupta-Dinu effect' [7].

The 'Gupta-Dinu effect' is natural outcome of Einstein's–relativity theory which necessitates a little modification in famous Lorentz formula, the extra little term is manifested as Gupta-Dinu effect. To explain it clearly, let us ask a question as 'what is the interaction between electric-current (producing magnetic field B) with a positive charge (Q) at rest (V = 0)'? As per the old known Lorentz formula (F = Q. V x B) there would be 'no' interaction i.e., force will be zero (F = 0) since V = 0. But the Einstein's relativity results-in [7] a modified Lorentz formula : F = Q. (V – v/2) x B, wherein v the drift velocity of electron in the electric-current. Hence as per the modified formula the electric current will have 'some interaction' even with the static charge ; i.e., the force will not be zero but F = - Q . v/2 x B because though V = 0 but v ≠ 0. In other words: 'a static (V = 0) positive charge (Q) will be attracted with a force F = - ½ Q .v x B towards the electric-current (producing magnetic field B) in which electrons are moving with a drift velocity v '. This interaction of electric current with static charge is called Gupta-Dinu effect [7], which is in fact a natural outcome of Einstein's-relativity reflected in the modified Lorentz formula. The extra force term F = - Q v x B/2 may be called Gupta-Dinu force or it can be better named as Einstein's force, since this extra term comes out due to Einstein's special theory of relativity.

Generally the Gupta-Dinu effect (the interaction of electric current on a static charge) is usually small as the extra term for the Einstein's force F = - ½ Q. v x B is very small, since drift velocity v is extremely small (snails speed). But in cold-fusion case, a very large number (say, of the order of Avogadro's number) of electrons are flowing in the palladium electrode as current (I = n.A.v.e) therein producing magnetic-field (B = ½ μ/π. I/r) , the cumulative Einstein's attractive force on deuterons due to the large number of electrons in the current may equalize or even overcome the Coulomb repulsive force between two (or more) positive deuterons. This may eventually require a minimum (critical) current density. Thus cold-fusion seems possible even on theoretical basis, as the biggest objection is thus overcome. Though Coulomb's force is much stronger than the Einstein's force, but the cumulative Einstein's force due to billion & billions of electrons in the current may possibly overcome the individual Coulomb repulsion between a few deuterons.

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Possibility of Nuclear-Fusion Occurring during Arc-Welding

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Nuclear-Fusion occurs at extremely high-temperature of the order of a few million degree Celsius, as in the core of Sun. Arc-welding is a fabrication-technique in which the metal pieces are joined by melting it with the heat of the electric-arc having a temperature of the order of a few thousand degree Celsius. Quite obviously it seems that there is no link of nuclear-fusion with arc-welding. The objective of this research-report is to tell that there exists a possibility of low-energy nuclear-reaction (LENR) occurring during arc-welding; and if it is so, it would open a new possibility of utilizing otherwise-difficult nuclear-fusion for energy-production.

In arc-welding quite-much amount of heat is produced, enough to cause intense bright-arc able to easily melt metals. No one has bothered to do the heat-accounting in welding, assuming that the heat produced must be equal to the input electrical-energy. The author (who is Ph.D. in welding from I.I.T. Kanpur), however, in-view-of various reasons such as the appearance of very-strong & intense bright-arc in welding as well as in lightning-arc, suspects a possibility of nuclear-fusion occurring within the arc. Note that the electric-arc is nothing but plasma i.e., hot ionized gases, so likelihood of nuclear-fusion of the positive-ions within the arc can not be ruled out. In usual welding (in air) heat accounting is quite difficult, so the author suggested to do underwater welding [1] experiment, wherein a better heat-accounting is possible since most of the heat-produced would be used up in heating & vaporizing the water therein.

Such experiment was conducted [2] in the institute of the university with the help of project-students under the author's

supervision. In underwater welding, arc stability is however poor; arc-stability (as it is known) could be improved by extra-coating over the electrode and making the water saline with salt. The rough heat-accounting in underwater-welding experiment reveals that at-least 25% more heat is produced than the input electrical-energy. This indicates that there is a possibility that a low-level nuclear-fusion that might be occurring within the arc. But exactly what nuclear-reactions could actually be occurring there, is yet to be investigated. But if any such nuclear-fusion occurs there, this would open a revolutionary vista for energy-production, say, through steam-generation in underwater welding. Theoretically too, fusion of positive-ions in the electric-arc seems possible; since a new-found 'Gupta-Dinu Effect' [3] predicts that positive-charges would be attracted towards electric-current.

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Deuteron Fusion using Pb Nanoparticles.

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Pb forms compounds with C and H(D). They can be frozen-confined in a suitably shaped shell. A large quick pulse of energy (e.g. from a Van de Graaff generator) through embedded Pb wires creates Pb nanoparticles with entrapped deuterons in and on them. The deuterons^{+} around the nanoparticle^{-} exhibit a smeared-flattened state function like an electron^{-} around a nucleus^{+} or a group^{+} of nuclei (e.g. a molecular orbit) by comparable mass ratios. A reduction of Coulomb barrier by a factor of 10^{-7} is calculated as possible. The strong-force source in the baryon is (thought of as) independent of the e^{-} charge field and can merge into another baryon. An experiment hereto is worth being carried out. An explosion-type event is ruled out due to the low-and-slow, nuclear-molecular 'ping-pong'-probabilities involved.

The so-called cold fusion may also be explained by the smearing of the deuteron/hydrogen wave function in a lattice of (heavier) ions and the chargelessness of quarks. The author finds no compelling evidence for assigning electric charges to quarks. The electric field ($>10^{-15}$ m) does not have its origin in the quarks ($<10^{-15}$ m). There is no possibility of a stable electric field below a femtometer. It will always get pushed out. This also harmonizes with the bag or drop model of the nucleus.

Dynamical Screening Effect on α-decay in Metal During Deuteron Beam Bombardment

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In the cold fusion studies, experiments with low-energy deuteron bombardments on various metals have revealed the existence of large screening for the D+D reaction in metal environment. However, values of the screening potential deduced from these beam experiments are usually much larger than those of calculations based on the Thomas-Fermi model. Thus, one may consider that the screening effect during beam bombardment is not necessarily same as that in the static situation, since conduction electrons are being excited during the bombardment. In the present work, we have tried to see such an effect in nuclear α-decay in metal.

In the α-decay, an α particle should penetrate a huge Coulomb barrier, which essentially determines the decay rate. As discussed so far for the DD reactions in metal, electrons surrounding a nucleus screen the Coulomb potential. Thus, if the effective barrier height between α-particle and daughter nucleus becomes smaller when the metal, where the decaying system stays, is being bombarded with the beam, we can expect higher emission rate of α particles during the bombardment. An enhancement factor of the decay rate for the difference of the screening energy(ΔUe=Ue(beamon)–Ue(beam off)) may be approximated simply as

$$F(\Delta Ue) \sim \exp(B \cdot \Delta Ue/(2E3/2)),$$

where $B = 21/2\pi Z1Z2\alpha(\mu c2)1/2$
(Z1,2: atomic number, α: fine structure constant, μ: reduced mass) and E is the energy of the α particle.

The experiment to obtain ΔUe has been planned by observing the decay of 147Sm which is an α-decay nucleus (T1/2 = 1.08 x

1011 y, Eα = 2.23 MeV) naturally exiting. A Sm plate of 0.2 mm in thickness is used as a target to be irradiated with a 15-keV D3+ beam whose current is about 30 μA. In order to compare the yield of α-decay, emitted α particles are detected repeatedly for 10 seconds with beam on the target and for 10 seconds without beam. From very preliminary measurement, we have deduced the yield ratio for beam on/off R(on/off) = 1.25 +/- 0.31, which is converted to ΔUe = 9.5 +9.5/-12 keV. This suggests an existence of a dynamical screening due to the beam bombardment on Sm metal, although much higher statistics are required to conclude clearly. It should be noticed that 9.5 keV of ΔUe for the Nd-α system corresponds to 80 eV for the D-D system.

We will discuss on the experiment in detail and give more accurate result on the change of α-decay rate.

Fusion of Deuterium Nuclei in TiD Systems Stimulated by X Rays

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In works [1,2] was shown that electron beam (J ~ 0.5-2.1 mA/cm^2, E = 30 keV) stimulated emissions of DD-reaction product (3 MeV protons), as well as high energy alpha from Pd/PdO:Dx and Ti/TiO:Dx targets. Here we present an evidence for a statistically significant emission of 3 MeV protons and high energy alpha from DD-reaction in experiments with Ti/TiO:Dx sample, stimulated by X rays. Plastic track detectors CR-39 were used for the detection of charged particles. Samples were electrochemically loaded in 1M D_2SO_4 solution in D_2O, then irradiated on X-ray installation (U = 120 kV, I = 5 mA, tungsten cathode) in air and were placed between two detectors covered with 11 μm Al and 25 μm Cu, respectively.

Yield of product of DD nuclear reactions is much higher than under the influence of the electron beam. First of all this is due to the significant increase of power radiation of X-rays in comparison with the electron beam, second fact that the X-ray radiation affects the entire volume of the sample, electrons only on its thin surface layer. Effect of electron beam [1,2] on the samples of Pd / PdO: Dx and and X-rays on Ti / TiO: Dx stimulate emission of 3 MeV protons with both irradiated and not irradiated side of the sample. Hence, nuclear processes take place mainly in the surface region of the sample, apparently, on the border of Pd - PdO, Ti-TiO. One reason for this situation – it is high concentration of deuterium at the interface metal - insulator, because of radiation-induced diffusion of deuterium in metals is much higher than that in metal oxides. Another possible reason – it is more high-energy deuterium atoms at the border than in the bulk, due to he nature of the plasmon mechanism of acceleration of atoms.

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Research into Excited Long Lived 0.6 – 6.0 Kev Energy Levels in the Cathode Solid Medium of Glow Discharge by X-Ray Spectra Emission

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The experiments were carried out using a device of high-current glow discharge, which consisted of a water-cooled vacuum chamber, water-cooled cathode and anode units. X-ray emission was removed through a diagnostic window placed above the cathode. The discharge was realized in H2, D2, Ar, Kr and Xe at the pressure 1 – 5 Torr using the cathode samples made of Al, Sc, Ti, Ni, Mo, Pd, Ta, W, at current up to 200 mA and discharge voltage of 3000-4300 V. The pulse-periodical power supply of the glow discharge was used. The X-ray spectra were registered in film using the curved mica crystal X-ray spectrometer.

The X-ray spectrum were registered both as bands of the continuum with energies ranging 0.6 - 10.0 keV and as spots resulting from the emission of series of high-density monoenergetic X-ray beams (with energies of 0.6 - 10.0 keV) characterized by small angular divergence. The X-ray spectra were repeatedly recorded during the Glow Discharge operation and after the Glow Discharge current switch off (for up to 20 hours afterwards). The X-ray emission bands energy correlated with K – L and L – N X-ray transitions. X-ray spectra include bands: K – M_3 X-ray transitions with 3.19 keV energy for Ar (discharge in Ar), L_3 – M_1 (1.65 keV) for Kr (discharge in Kr), L_1 – N_3 (2.503 keV) for Zr (discharge in He), L_2 – M_4 (2.395 keV) and L_2 – N_2 (2.623 keV) for Mo (discharge in He). The X-ray monoenergetic beams were recorded as dark spots. The spots energy were determined the cathode samples material. All the experimental results have 100% reproducibility.

The obtained results were the direct experimental evidence of existing the excited metastable energy levels with the energy of 0.6-10.0 keV in the solid of the cathode sample.

Neutron Emission Measurements During Loading Tests on Solid Specimens and Confirmations by EDS Analysis

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Neutron emission measurements, by means of He^3 devices and neutron bubble detectors, were performed during three different kinds of loading tests on natural and artificial materials: (i) under displacement control, (ii) under cyclic loading, and (iii) by ultrasonic vibration.

The materials used in compression tests under displacement control were marble, granite and concrete, selected in that they present a different brittleness index [1,2]. For natural materials, such as granite and basalt were also conducted cyclic and vibrational loading tests in the frequency range comprised between 2 and 2x104 Hz.

Since the analyzed material contains iron, our conjecture is that piezonuclear fission reactions involving fission of iron into aluminum, or into magnesium and silicon, should have occurred during compression damage and failure. This hypothesis is confirmed by Energy Dispersive X-ray Spectroscopy (EDS) analysis performed on external and fracture surfaces belonging to specimens used in the tests.[3] These laboratory evidences appear to be strictly connected with recent neutron emission detections in correspondence to seismic activity and appreciable earthquakes at the scale of the Earth's crust [4,5] and led to consider that the present natural abundances of aluminum (~8%), silicon (28%) and scarcity of iron (~4%) in the continental crust should be possibly due to piezonuclear fission reactions[6].

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Piezonuclear Neutrons and Transmutations in Iron Bars Treated by Ultrasounds

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In the last six years we carried out experiments about piezonuclear reactions [1, 2] in which we applied ultrasounds to solutions of water containing atoms of Iron and from which, thanks to ultrasonic cavitation, that brings about a violent bubble collapse, we obtained neutron emission. In the wake of the success of these experiments, we made a heuristic hypothesis that a process as abrupt and violent as a bubble collapse in cavitation, could take place in bars of Iron suitably subjected to ultrasounds. A solid metal always contains a gas porosity, in fact. This gas porosity may be looked at as being made of bubbles dispersed in the metal.

The compressions of these "bubbles" due to ultrasounds make them collapse or suddenly reduce their volume and brings about a violent and abrupt squeeze of the Iron atoms that surround the cavity of gas in the same way as bubble collapse crushes those in the interface gas liquid of the bubble. Thus, by an ultrasonic machine pretty much similar that used in the previous experiments [1-5], we subjected to ultrasounds of 19 Watts several bars of Ferrite and steel 20 cm long and with circular base with a diameter of 2 cm. After detecting neutron bursts by a neutron counter that, hence, corroborated our heuristic hypothesis, we measured, by a neutron spectrometer, the spectrum with ultrasound turned off (background) and with ultrasounds turned on. The latter has a fairly clear log-normal shape which makes it completely different from the former. A second very peculiar evidence was obtained, after one hour of ultrasounds applied to the bars. Circular shaped damages, with a diameter ranging from 2 to 3 cm, appeared on the lateral surface

of the treated bar. The surface of these spots is rougher and has two concentric zone which, from the centre to the border, has a whitish and brownish colour respectively. A suitable treatment by diluted hydrochloric acid, confirmed that these damages are not made of Iron oxides. Moreover, a x-ray micro-analysis, by an SEM, showed an amazing variation of the local superficial concentration in weight of Iron, Dysprosium, Carbon and Oxygen, which from 91.92 %, 4.12 %, 2.37 % and 0 % respectively, on an undamaged spot, became, 44.45 %, 0 %, 19.80 % and 29.27 % respectively, at the centre of the damaged part. With the transmutations, that were reported by many a one works of CMNS [6] and by other works [7-10], in mind, we ocalized ed that these variations of concentration where due to piezonuclear reactions that had taken place ocalized in the spots where the damages appeared. If this hypothesis will be corroborated by other evidences and further analysis like x-ray and neutron diffractometry and neutron activation, that are just being carried on, it will be possible to state that these spots are the volumes of solid iron (condensed matter) where the three conditions on energy, space and time [11-14] for piezonuclear reactions to be ignited, were reached or equivalently where the nuclear active environment (NAE), made activate by pressure, was located. In this sense, it will be possible to carry out focused analyses in order to study the static features of the NAE, both around the already damaged active volumes and, by suitable shortening the application of ultrasounds to the bars, around the volumes where the damages begin to appear. The main purpose of this work is to bring to the attention of other research teams these peculiar outcomes with the chance to find similar ones that may corroborate and enrich each other.

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Cavitation BEC Compression Pulse Explains Experimental Results

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Sonofusion, within a natural but controlled cavitating system, features deuteron BECs during a picosecond, ps, and electromagnetic, EM, spherical compressing pulse producing $2D^+$ fusion events. The BEC cluster is the key to sonofusion and relates to known muon and Inertial Confined Fusion. In these cases deuteron fusion depends on the DD separation or densities. At 10^{30} D^+/m^3, muon fusion occurs in low T environments. Sonofusion's experimental results fit BEC's ps squeeze, dense D^+, and free e^- EM pulse, and D^+ evaporative cooling pulse.

The cavitation bubble collapse produces sonoluminescence and 10^7 particles, e^- and D^+, a dense plasma implanting jet with a femtosecond, fs, charge separation. Some of these deuterons during this fs, will cluster. Mobile free electrons are spherically accelerated coulombically producing an EM pulse squeezed cluster of increasing density and BEC character. During this ps the coulombic deuteron escape pressure is much less than the cluster's compressing pressure.

During the picosecond pulse, evaporation from the surface of the cluster cools the remaining BEC deuteron contents maintaining a relatively low temperature, T of about 4000 K, compared to the BEC critical temperature, Tc.

The Shell and Collective Model of the individual cluster deuterons in the absence of electrons show that the next energy level above groundstate is more than its dissociation energy of 2.32 MeV. The Collective Model suggests possible deuteron rotational levels, ~ .05 MeV, due to symmetry considerations, and leads to the transient BEC's high Tc. The condensate fraction is about $1-\{T/Tc)^3$.

The following are some experimental results. The fusion heat from the cluster progresses as a spherical heat pulse through the target lattice and escapes as vaporous ejecta into the circulating D_2O. The fusion products are in the vaporous ejecta. Millions of pits, ejecta sites, in the target lattice are continually changing as the lattice surface changes with each acoustic cycle. These ejecta sites in the target foils have been surveyed by scanning electron microscopy.

The gases have been collected from over the circulating D_2O in stainless steel sampling volumes and analyzed by mass spectroscopy. He^4 and heat has been found and measured as fusion products from the cavitation sonofusion process. Measurements for gamma radiation fusion products were made with no evidence of any long-range penetrating radiation products.

The fusion environment in the BEC explains the measured fusion products of He^4 and heat. Fusion energy is converted into these products within the BEC squeezed environment via instant transfer of fusion energy to cluster deuterons.

Advances in Deuterium Permeation Transmutation Experiments

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Low energy nuclear transmutations in condensed matter have been observed in the nano-structured Pd multilayer complex, which are composed of Pd and CaO thin film and Pd substrate, induced by D2 gas permeation through Pd multilayer complexes[1]. Transmutation reactions of Cs into Pr, Ba into Sm and Sr into Mo were observed. Especially, transmutation of Cs into Pr has been confirmed by "in-situ" measurements using x-ray fluorescence spectrometry (XRF) at SPring-8 in Japan. Similar experiments have been performed by some researchers and positive results have been obtained in some cases. However, more systematic experiments are required for making clear the nature of this permeation induced transmutation.

A micro-beam NRA system, by means of a resonant nuclear reaction $^{1}H(^{15})\gamma\alpha N,^{12}C$, has been developed for the purpose of the 3D mapping of the hydrogen distribution in solids under a CREST program of JST(Japan Science Technology Agency)[2]. Using this system, we measured hydrogen density near surface in Pd multilayer thin film during permeation. Obtained results on H/Pd distribution in Pd/CaO thin multilayer film will be reported.

We are trying to make clear what elements can be transmuted by our permeation method. Preliminary results on W transmutation experiments and theoretical consideration based on the first principal calculation will be presented.

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Characterization of Cathodes Before and After Electrolysis

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We previously reported that palladium cathodes developed microscopic rimmed pits and evidence of localized melting and recrystallization during electrolysis in heavy water electrolyte[1,2]. We also detected pits on a titanium cathode after electrolysis in a similar electrolyte[3]. For both Pd and Ti, anomalous elements were detected in the pits but not in the surroundings. Mass spectrometry of Pd cathodes after electrolysis produced evidence of inversion of isotopic abundance [4]. Our recent research includes studies of the microchemical composition of scratches made with a razor blade on the surfaces of Pd cathodes before and after electrolysis. Analyses were made with an energy dispersive spectrometer from the surface to the bottom of each scratch. Each spectrum gave the chemical analysis of about one cubic micron of the cathode. These results and their interpretation will be presented.

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Pd Isotopic Variations After LENR Experiment

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Inspired by work done by A.G. Lipson, et al. in 2002 , this report details the variation of isotopic abundance after electrolysis experiments on palladium cathodes immersed in heavy water electrolyte. We provide evidence of isotopic variations by ion beam milling to various surface depths in the palladium cathode before and after low energy nuclear experiments. The isotopic measurements are made with a secondary ion mass spectrometer. Scanning electron microscopy is used to provide high resolution images which show the topography of cathodes after experiments, as well as the depth profiles milled into the cathode. An energy dispersive mass spectrometer is used to provide elemental composition of the cathode.

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Characteristics and Energetics of Craters in LENR Experimental Materials

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Craters with dimensions (diameters and depths) on the order of 10 to 100 micrometers are often observed on the surfaces of cathodes after electrochemical LENR experiments. They are strong evidence of very local and fast energy releases. This paper will provide a compilation of the characteristics of such craters from many papers. Then, the following questions will be addressed:

1. Do the rapid energy-release events, which cause craters, occur on the surface of cathodes or within them near the surface?

2. How much energy is needed to cause the formation of craters of the kinds observed in various cathode materials?

3. How much of the crater-forming energy winds up as sound or light, which might be diagnostically useful?

4. What fraction of the total excess energy might be released by crater-forming events, and is it practically significant?

5. If much of the excess energy is released during crater formation events, will cathode erosion provide a practical limitation on the lifetime of commercial LENR energy sources?

The overall goal of this study is to ascertain the utility of craters for (a) learning basic information about LENR mechanisms and (b) designing engineering energy sources. In addition, the scaling of craters will be examined to see if the energetics and dimensions of larger craters can provide any information of use for understanding of the energies of formation of LENR craters. Craters with diameters varying by over 10^6 were studied :

Craters of widely different size scales: From the left, a meteor impact crater about 1.15 km across in Arizona, a crater 390 meters in diameter from a nuclear device test in Nevada, the crater about 72 meters across from a TNT explosion in Hawaii, an Al hypervelocity impact target with a 33 mm diameter crater, and a crater 0.75 mm across at the focus of a high powered laser. The energy needed to form each of these craters is known or can be estimated. Hence, it is possible to extrapolate the energy and size data to estimate the formation energies of individual craters in LENR cathodes.

Stimulation of Low-Energy Nuclear Reactions in the Gas Discharge.

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The review of major factors of influence on intensity of low-energy nuclear reactions in the gas discharge is presented. Intensity influences (contribution) of each factor is confirmed by experimental data.

The role of type of ions, the intensity of ions flow, of ions dose, voltage, temperature and current type on isotopes ratio change and quantity of additional elements is estimated. The contribution of superficial changes and cathode material is noted.

Abnormal effects in the materials irradiated with low-energy ions in the gas discharge are noted. Structural surface changes, changes of elements structure and isotopes structure for Pd, W, Ti and other after an irradiation by ions of hydrogen and deuterium in the gas discharge (GD) are described.

The basic analyses were executed various methods of mass-spectrometry and gamma spectrometry. It is shown, that considerable changes of isotopes ratio, occurrence of additional elements were accompanied gamma and x-ray radiation. Changes of isotopes ratio reached the factor 2-1000, quantity of the additional elements which are not detected to an irradiation in the gas discharge were from parts of percent to tens. In the majority of experiments the isotopes with mass numbers less and more than the basic matrix material were observed. Weak gamma radiation and the subsequent transformations after an irradiation by ions were noted. So isotopes of tungsten continued transition to isotopes with mass numbers smaller, than tungsten isotopes after experiment finish. Intensity of isotopes with mass

numbers 169, 170, 171, 178 and 180 on mass spectra increased (grown) from 5 to 400 times (from 5-50 counts per second (cps)in an initial foils to 100-20000 cps after experiments). Comparison of thermo ionization mass-spectrometry data and gamma-spectrometry data has allowed to assume found after experiments following isotopes:

$$^{169}_{70}Yb \; ; \; ^{170}_{72}Hf \; ; \; ^{171\,m}_{70}Yb \; ; \; ^{172}_{72}Hf \; ; \; ^{178}_{70}Yb \; .$$

Observation of isotopes with mass numbers bigger and smaller of matrix material isotopes allows to believe, that the gas discharge stimulates low-energy nuclear reactions.

All effects of primary known work of the Indian scientists of 1990 are reproduced in the gas discharge.

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Observation of Pits & Pit Swarms in Plastic Solid-State Detectors Exposed in Space and their Erzion Interpretation

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In Plastic Solid-State Detector (PSSD) exposed there were observed an intensive cover of the films from reams of solid-state detectors by pits (tracks with special pit form & small depth) after their exposition in a free space on the satellite orbit. For their explanation it has been offered the mechanism of nuclear interaction of hypothetical neutral cosmic space Erzions. To proof this hypothesis the further measurements of production of nuclei Tritium (H^3) and radiocarbon (C^{14}) in films material has been lead by a radiochemical method. The depth distribution of such pits by means of a microscope for different pits diameters has been in more detail investigated and additional film calibration in a beam of nuclei of hydrogen & nitrogen with energy 0,1-5 МэВ has been executed. The received results of calibration, measurements of production of Tritium and radiocarbon in exhibited films and new visual researches of tracks depth distribution have given the new information on conformity to the put forward hypothesis.

For further check of the pit nature by Erzion hypothesis it has been executed the search of large (~100) pits swarms in Plastic Solid-State Detector (PSSD) exposed in Space. It was analyzed films of different kind of PSSD (CN, CR, CZ) from different piles & satellite flights. As a result it was observed a lot of such swarms and some of them were correlated with the end of high ionization track. All this expected from stopping negative charged cosmic ray Erzions. Such pictures are presented and discussed in report.

Characterization of Pd·Ni·Zr Oxide Compounds

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The phenomenon of anomalous generation of heat and He^4 by deuterium / protium absorption of nano-sized Pd powders first reported by Arata and Zhang [1] has been extensively studied in these years. A twin absorption system was installed by Kobe Group (Kobe Univ. and Technova Inc.) for simultaneous D_2 and H_2 gas absorption experiments using Pd micronized particles and oxide composites of nano-sized Pd and Zr [2]. The samples tested so far include the 0.1-μm-diam. Pd powder (Nilaco Corporation) [2], 300-mesh Pd-black powder (Nilaco Corp.) [2], a Pd·Zr oxide composite "PZ" (Santoku Corporation) [3-9], a Ni·Zr oxide composite "NZ" (Santoku Corp.) [4], a Pd·Ni·Zr oxide composite "PNZ" (Santoku Corp.) [4], and another Pd·Ni·Zr oxide composite "PNZ2B" [8,9] provided by Brian Ahern, Vibronic Energy Technologies Corporation.

The phenomenon is thought to be very sensitive to mesoscopic structure of the sample as well as the degree of oxidization [6-9]. To clarify the mechanism of anomalous heat evolution, study of material characterization is discussed in the present paper. The characterization methods include SEM, XRD, Laser Raman microscopy, TEM and PIXE analyses. Preliminary measurements have indicated some structural changes after absorption experiments.

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Effect of Forced Oxidization on Hydrogen Isotope Absorption/Adsorption Characteristics of Pd·Ni·Zr Oxide Compounds

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In order to confirm heat and He^4 generation by deuterium (D) absorption in nano-sized Pd powders reported by Arata and Zhang [1], we established a twin absorption system for simultaneous D_2 and H_2 gas absorption experiments using Pd micronized particles and oxide composites of nano-sized Pd and Zr [2]. In the present work, three kinds of samples are tested; the Pd·Zr oxide composite "PZ" and a Pd·Ni·Zr oxide composite "PNZ", both supplied by Santoku Corporation, and another Pd·Ni·Zr oxide composite "PNZ2B" provided by Brian Ahern, Vibronic Energy Technologies Corp. Simultaneous introduction of the D_2 and H_2 gases into each reaction chamber from each reservoir tank is performed with flow rate control by "Super Needle" valves. The as-received samples are oxidized to some extent. To investigate the effect of oxidization on sorption (absorption and/or adsorption) rate and heat release rate, we applied forced de-oxidization and forced oxidization (to make 5 – 10 % PdO or NiO) to the samples. Oxidization was made at 473 K or 573 K in oxygen gas at a pressure of 0.3 MPa(a), while de-oxidization was made at 573 K in D_2 (H_2) gas at a pressure of 0.3 - 0.5 MPa(a). The D_2 (H_2) absorption runs have revealed the following facts for the 1st phase [2, 3], where predominant heat evolution associated with hydrogen isotope sorption proceeds;

1. Forced de-oxidization of the PZ and PNZ samples gave greatly reduced loading ratio D(H)/M and heat release rate compared to very large values for as-received samples, which were recovered significantly by forced oxidization.

2. Time-resolved measurements have been applied to the PZ samples to reveal existence of sub-phases, 1a and 1b. In the 1a-phase, the anomalously large heat evolution proceeds under relatively low pressure below 3 kPa, while relatively small amount of heat is generated in the 1b-phase under relatively high pressure (3 – 10 kPa) with significant isotope dependence. Oxygen incorporation is necessary for the 1a-phase to appear.

3. Time-resolved specific sorption energy, or differential heat of hydrogen uptake, $\eta_D(t)$ ($\eta_H(t)$), defined as the output energy per one hydrogen isotope atom absorbed/adsorbed is very large; η_D (η_H) ≈ 1.33 eV/D (1.15 eV/H) for the 1a-phase, and η_D (η_H) ≈ 0.47 eV/D (η_H ≈ 0.41 eV/H) for the 1b-phase, respectively as averaged values in their intervals.

4. For the PNZ2B sample, the effect of de-oxidization on the rates is very modest, and forced oxidization made almost perfect recovery. We observed anomalous change of gas pressure in the early stage of sorption caused probably by the effect of surface NiO layer, and anomalously large D(H)/M ratios exceeding 3.0. The averaged value of the differential heat of hydrogen uptake, η_D (η_H) ≈ 0.61 (0.55) eV/D(H), has a modest isotopic effect of about 10%. However, similarly to the case of PZ samples, η_D sometimes exceeded η_H several times in some time intervals, which might be of nuclear origin.

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Are Oxide Interfaces Necessary for LENR?

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Several theoretical calculations have shown that deuterium atoms are not sufficiently close in bulk palladium for fusion to occur.[1] Other theories suggest that high electric fields are necessary to initiate LENR. These fields are often associated with interfaces and need not be generated by some collective property of the material.

Certain oxides, such as Zeolites, are known to have electric fields as high as 9.5V/nm inherent in their structure.[2] This could be one reason gas loading may be successful for observing LENR in Zeolites.[3] In electrolytic loading no oxides exist initially as the oxides may inhibit high loading with deuterium. However, if one intentionally or accidentally contaminates the surface with oxides during the electrolysis and after deuterium loading, such an interface could be generated.

We will briefly discuss the role of oxide structures in LENR and present experimental data where excess heat is only triggered during electrolytic loading when such structures are generated.

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The study of the Fleischman&Pons Effect through the Materials Science Development

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The state of the palladium metal has been identified on the basis of statistical data to play fundamental roles in producing the Fleischman-Pons excess heat effect. The deuterium loading dynamics and its equilibrium concentration are mostly controlled by the metallurgy; a minimum threshold loading (D/Pd ˜ 0.9) is necessary to observe the excess. The crystallographic orientation is also correlated with the phenomenon such that mainly <100> oriented samples gave the highest reproducibility. A specific cathode surface morphology, identified by means of the power spectral density function, represents an additional identified condition to observe the effect.

Materials specimens respecting the characteristics described above have been used to obtain a transportable reproducibility. Designed materials giving excess power have been produced but the amplitude of the signals and full reproducibility are not yet achieved. Other features of the material such as the nature and content of impurities and defects seems to be crucial in obtaining the required palladium characteristics.

Correlation Between Surface Properties and Anomalous Effects in F&P Experiments

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The understanding of the physical mechanism which is responsible for anomalous excess heat production during F&P experiments is very challenging and it is complicated further by the high interdependence among the different involved features. A strong correlation has been observed between this anomalous phenomena and palladium surface related properties such as easy loading at low current, crystal grain distribution, crystallographic orientation, surface morphology [1]. In this work a review is proposed of F&P experiments giving anomalous heat production and their correlation with cathode surface properties, deuterium kinetics in palladium lattice and electromagnetic interactions at metal/electrolyte interface.

References:

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Robust Performance Validation of LENR Energy Generators

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The development of any prototype energy generator based on new physics raises the requirement for rigorous performance testing, particularly in the evolving area of low energy nuclear reactions (LENR). Before such devices can transition into the market place, independent and reliable validations are required. Such validation testing is a prerequisite to the sale of existing or evolved prototypes, acquisition of any rights to intellectual property, or investment in the further development of technology embodied in the existing prototypes. Prospective customers and investors should demand to learn the performance characteristics, and be able to review the results of such rigorous tests.

The primary purpose of this paper is to stimulate discussion on how to perform a test to provide independent validation of a claimed new energy source. The goal is to generate guidelines for how an independent tester can provide sufficient details about the measurement and specifications of device performance, so that the results of the prototype device performance tests can be accepted. Even though the internal details of the early power generators might be proprietary, energy sources offered for sale can and should be accompanied by a detailed test methodology description, independent test results, and adequate performance specifications. Our system and methodology can satisfy the needs for rigorous testing and adequate data.

The initial claimed LENR energy generators are expected to produce excess heat, with later versions producing electricity from heat. Thus, heat measurements with well-calibrated and redundant sensors are required. Many types of calorimeters have already been used for LENR experiments. Of them, mass flow calorimetry seems best adapted to prototype generator performance validation. We developed a water flow system and protocols that can accurately measure the rates of input and output matter and energy flow over extended periods of time, thereby providing energy gain values for devices producing kilowatts of excess heat. Diverse meters and methods were employed to measure the water flow rate. Thermocouples and infrared pyrometers gave the input and output water temperatures. Any electrical or gas inputs should also be measured redundantly. The system is best suited for power measurements between 0.2 to 20 kW, although that range could be extended to higher powers. It was tested with a commercial water heater at the 10 kW level. Additionally, if the source of energy is claimed to be from new physics such as LENR, tests must be conducted for a sufficiently long time to eliminate the possibility of stored chemicals contributing to output energy from the device. Hence, the volume and mass of the device must be known. Controls, calibrations, and stability measurements are also needed. They, and all other aspects of the validation testing, must be thoroughly documented, and any expected safety issues should be disclosed.

Optimization of LENR Energy Generators

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Reproducibility and controllability of energy sources are required for their commercialization and practical use. Sources of energy based on Low Energy Nuclear Reactions (LENR) are still unpredictable and inadequate for routine private or industrial use. However, the ability to replicate and control some LENR experiments is improving. It is not unreasonable to anticipate eventual mastery of both reproducibility and controllability. Then, it may be possible to build practical prototypes and products.

When engineered devices enter the market, they are usually not optimized for performance or for the low costs of acquisition, operation and maintenance. This reality is expected to apply to the early LENR energy generators. In this paper, we focus on the optimization of the performance of LENR devices, including both early prototypes and, especially, later commercial products. The energy gain factor (energy out/energy in) is the primary metric for performance optimization.

McKubre and his colleagues provided an empirical equation for electrochemical LENR experiments. It relates power output due to nuclear reactions to the electrical current density at the cathode surface, the ratio of deuterons to Pd atoms within the cathode, and the rate of change of that ratio. We employed that equation, term by term, to consider potential improvements in the output power due to LENR.

Swartz developed and analyzed the concept he calls the Optimal Operating Points (OOP) based on high-impedance and other electrochemical experiments. Optimization of LENR energy gains using on the OOP concept will be examined.

Next, we consider improvement of the output of gas-loaded LENR energy devices, such as those reported by Arata and Zhang. Many people expect that gas-loading approaches to LENR will be the first commercial devices. Hence, their optimization is important.

It has been shown experimentally that various stimulation or agitation methods can enhance excess energy production. We review the methods that have already been employed, and considered agitation methods, which are available for future experiments

Finally, the central role of materials for performance optimization of LENR energy generators will be examined. It is expected that materials optimization will prove to be very important for commercial LENR devices.

Technology of Environmentally Clean Remediating Radioactive Waste Based on Low Energy Transmutation of Radioactive Nuclides

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At present intensive investigations are being carried on in many countries with a view to developing effective methods of treating radioactive waste (RW). In most cases those works are aimed at providing isolation of RW from environment and long term safe storing RW of different origination. One of the directions of developing such technologies with application to low and intermediate level RW stipulated significant decreasing of the waste initial volume and converting it into a form suitable for disposing it of for a long term storage.

It is recognized now by many specialists that the most perspective technology for solving this problem is the technology of plasma pyrolysis of the organic components and melting inorganic part of RW and converting it into the form of vitrified slag. Provided the appropriate technical solution implemented the technology stipulates incorporating (capturing) 90-95% of the entire radioactivity of the waste material inside the vitrified slag as well as actual absence of dangerous discharging of radioactive and other hazardous products into the atmosphere.

Such technology has been developed in Russian Research Center "Kurchatov Institute" and realized in Russia in cooperation with Scientific and Industrial Association "Radon" at two pilot facilities – installations "Pyrolis" and "Pluton" – and at present, based on those two installations, a number of new facilities of higher capacity for processing RW at nuclear power plants and processing waste of different originations. It is worth to note that these Russian facilities obtain a number of significant

advantages as compared to other known installations implementing analogous technological principles, in particular, the "PACT" installations developed and manufactured by the "Retech" US company.

However, even these sophisticated installations do not solve completely the problem of RW remediation since the secondary product of plasma processing, though being highly stable, nevertheless remain radioactive and hence needs special handling and storage space.

Meanwhile, thanks to the success in research of low energy transmutation of nuclei of chemical elements, now there has appeared a possibility of solving the problem of utter remediation of RW. The results of experimental and theoretical research of a group of Russian scientists at the Dubna Center of Applied Physical Research (published in the journal "Annals de la Fondation Louis de Broglie", vol. 28, № 2 2003.

Web-site:http://FondationLouisdeBroglie.org Article: Low Energy Transmutation of atomic Nuclei of Chemical Elements by V.Kuznetsov et al.) allow to hope that the newly discovered method of electromagnetic impact on radioactive materials that results in transforming unstable isotopes into stable ones and such process is not accompanied with any ionizing irradiation. It was determined that low energy transmutation is actually a threshold nuclear reaction of resonance nature and of exothermic type which makes it energetically advantageous. According to their findings in order to initiate reaction of transmutation radioactive material is placed into special reactor and subjected to irradiation with electro-magnetic energy of specific frequency, amplitude and topology. The authors of that discovery determined that the process of transmutational processing RW may take from decades of minutes to several hours depending on the isotopic composition of radioactive compound and its concentration. The highest efficiency of the process is to be achieved when working with concentrated mixtures.

Such conclusion makes it reasonable to stipulate that the most effective approach towards RW remediation may become combination of the above mentioned plasma processing technology which provides concentration of dissipated radioactivity into slag compound thanks to the capability of the plasma process to capture most of the radioactivity provide almost 100-fold shortage of the slag volume as compared to the initial volume of the material accepted for processing, - combination of the same with the process of stabilization of the radioactive slag in special transmutation reactor. The design of such reactor has been developed. The task of today is recognized to be practical creation of an experimental unit of such reactor based on the principles found by Russian scientists.

Technology of Wasteless Low Cost Desalinating Sea Water Based on Low Energy Transmutation of Chemical Elements

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The problem of manufacturing fresh water is highly acute in many regions throughout the world. The range of using desalination of sea water mostly depends upon the economical characteristics of the desalination process which are determined by power consumption because so far power consumption plays the decisive role in determining the final cost of fresh water produced. Another problem related to desalination of sea water is the environmentally harmful consequences of disposing off the secondary highly salted residual solution back into the sea.

Nowadays the most sophisticated technology of desalinating sea water is accepted to be the technology of reverse osmosis. Of later years the main efforts in developing the technologies of desalinating water were aimed at improving the existing technologies and developing sophisticated ones as well as their combination in hybrid systems with a view to lowering the specific cost of portable water produced and raising the efficiency of the desalinating installations.

The goal of developing the innovative technology of desalinating sea water was to exclude the dangerous influence of sewage water on fish and sea vegetation.

The key point of the technology is implementation of the process of low energy transmutation to provide transition of atoms of salts to silicon oxide (sand) and gases. Both sand and gas are easily separated from water. The degree of final salinity of water can be changed. Transmutational radiation is generated by special beam generators (TM-generator).

The full equations of transmutational reactions taken place under the influence of TM-radiation are pretty complex and depend on specific chemical composition of sea water processed. The base equation of transition looks as follows:

$$\Sigma salts \Rightarrow NSiO_2 + MCO_2 + KH_2 + LO_2^{17} + lv + Q(kcal)$$

where the weight coefficients are determined by sea water chemical composition, frequency characteristics of TM-generator and amplitude of TM-radiation. The reaction is exothermic and the excess heat can be used for practical purposes which makes the final cost of the desalinated water even cheaper. The Transmutational

Desalinating Reactor (DTR) destroys salt completely. Sand, carbonic gas, an isotope of oxygen O^{17}, hydrogen and heat will be obtained as waste. Sand can be used in construction, heat and hydrogen for heating and generating electric power, O^{17} can be used in the industry.

The preliminary estimations of the main parameters of such desalination technology are as follows:

Input electric power — 500÷1,000 kW
Productivity of installation – 1,312 m^3/day
Cost of the desalinated water – 0.48 €/m^3

The desalination installation (DTR) is proposed to be combined with a transmutational power generator TPG-10 to supply the installation with electricity. It will make the cost of desalinated water ~ 0.02 €/m^3. As the output of TPG-10 is 10 MW it can supply ~ 15÷16 desalination installations. The set of 15÷16 DTR will produce ~ 21,000 tons of portable water per a day at the price of 0.02 €/m^3.

The total estimated costs of the project amounts approximately to 3.8 million €. It will be a true technological breakthrough in the market of the desalinated water.

Hot and Cold Fusion for Energy Generation

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Sixty years of research on hot fusion have cost about $20B. Only one of the dozens of experiments has barely reached breakeven, the point at which the energy produced is equal to the energy spent for its production. Twenty years of work on "cold fusion" cost less than $0.2B. Energy amplifications exceeding 10 for the Palladium-Deuterium system, and more than 100 for the Nickel-Hydrogen system, have been reported, but not verified. Hot fusion is understood and may result in large power plants in several decades. "Cold fusion", now called Low Energy Nuclear Reactions (LENR), remains a scientific mystery. If adequately funded, LENR could lead to safe, non-radioactive, green, small, distributed nuclear energy sources in less than two or three decades, well before hot fusion can produce commercial power.

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