ENEA

ICCF-15

15th International Conference on Condensed Matter Nuclear Science

Roma, Italy

October 5-9, 2009

Historic view of Rome by Spode, 1811

ABSTRACTS

15th International Conference on Condensed Matter Nuclear Science (ICCF15)

Roma, October 5-9, 2009

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Session 7: Material Science

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POSTER SESSION

Oral Papers

CHEMISTRY CREATIVITY AND FLEXIBILITY AT SERVICE OF ENERGY PROBLEMS

Luigi Campanella

President of Italian Chemical Society, Italy

Chemistry is surely the most creative and flexible science: this is shown by the history of Chemistry able during the time to change the target of the research in order to answer the needs from society,changing dynamically even they.In the field of energy this statement is particularly true as with the time processes of generation,materials involved,methods of impact assessment have been changed to follow the progress of the reasearch and to exploit the obtained results.The ability to modulate the surface of a material has become a further opportunity.The aim is not only to progressively substitute fossil fuel with renewable ones but also to perform it considering economical and social compatibility.

AN OUTSIDER'S VIEW OF THE SIGNIFICANCE OF THE FLEISCHMANN-PONS EFFECT

R.V. Duncan
University of Missouri

In a CBS 60-Minutes segment that aired in April, 2009, Dr. Fleischmann stated that he had two regrets regarding his press conference through the University of Utah in 1989: First, he regretted referring to this fascinating excess heat effect as 'fusion', and secondly he regretted holding such a high-profile press conference to announce his discovery with Dr. Pons. These comments by Dr. Fleischmann provide a retrospective on why this field has not emerged more rapidly to date, and his comments contain the key regarding how to advance this field of study in the future. There is ample experimental evidence that suggest that the excess heat effect is real, but the underlying cause of this excess heat remains unknown, as I expect it will be for many years to come. There are a few very interesting reports of particle emissions and ^{4}He gas generation from deuterium-loaded palladium, but much more work is necessary to explore this further and to determine if this is related to the physical origin of the excess heat effect. Experiments are needed now to determine if these excess heat levels may be scaled up and obtained at higher heat rejection temperatures. Science is fundamentally empirical, so scientists must always be prepared for surprises that challenges accepted thought. But the Scientific Method, which strives to disprove the hypothesis through experiment, must be followed always, with no exceptions.

COLD FUSION LENR; ONE PERSPECTIVE ON THE STATE OF THE SCIENCE

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With recent publicity outside the CMNS field it has become increasingly important to clarify in non-specialist terms what is known and what is understood in the general field of so called Low Energy or lattice Enhanced Nuclear Reactions (LENR). It is also crucial and timely to expose and elaborate what objections or reservations exist with regard to these new understandings. In essence we are concerned with the answers to the following three questions: What do we think we know? Why do we think we know it? Why do doubts still exist in the broader scientific community?

The author will review progress in the LENR field with primary focus on the experimental work performed at SRI by and with its close collaborators (ENEA Frascati, Energetics and MIT) with a view to define experiment-based non-traditional understandings of new physical effects in metal deuterides. This review will be performed using the following methodology:

i. What initial hypothesis was proposed?
ii. What experimental methods were employed?
iii. What results were obtained?
iv. How were these results interpreted?
v. What new understanding was achieved?
vi. How does this fit in the framework of modern physics?
vii. What alternative explanations, or objections have been proposed?
viii. How can these objections be countered or incorporated into an improved understanding?

An X-Ray Diffraction Study of Lattice Expansion and Phase Transformation in Electrochemically Loaded Palladium Hydrides

D.L. Knies[i], V. Violante[ii], K.S. Grabowski[i], J. Hu[iii], D.D. Dominquez[i], J. He[iv], S.B. Qadri[i] and G.K. Hubler[i]

Time resolved, in-situ, high-energy x-ray diffraction was performed on modified Fleishman-Pons electrolytic cells during electrochemical loading of palladium foil cathodes with hydrogen and deuterium. Concentrations of H and D up to 1:1 in 0.1 M LiOH/LiOD in H_2O/D_2O electrolytes were obtained with lattice constant data monitored throughout the range of concentrations. In addition to data on lattice constant versus H or D concentration and palladium hydride resistivity, some indication of the rapidity of loading and deloading of hydrogen from the Pd surface was obtained. The alpha-beta phase transformations were clearly delineated but no new phases at high concentration were definitively determined.

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THE DEVELOPMENT OF A LOW COST DIFFERENTIAL THERMAL ANALYSIS SYSTEM AT THE NAVAL RESEARCH LABORATORY

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A significant barrier to the study of the Fleischmann-Pons Effect (FPE) is the availability of a low cost, simple-to-understand and sensitive calorimeter. While heat conduction and mass flow calorimeters typically give a linear response over their operational range, they require very stable environmental conditions and stable baselines over several weeks to provide sub-mW and <100 mW sensitivities, respectively. The mass flow systems are further complicated by the requirement to pump and accurately measure the flow of very small amounts of liquid. The cost of equipment to build such calorimeters and to accurately measure the appropriate observables can be cost prohibitive. Some of these environmental constraints can be relaxed by the use of identical sample and reference cells connected by thermoelectric modules (TEM) to the same large thermal mass. The basic design is to surround a test tube with a good heat conductor and transfer some of the heat generated during the experiment to a TEM attached to the large thermal mass. With the availability of both low cost, high-resolution, high-channel count analog to digital converters and moisture resistant thermoelectric modules (TEM), the design of high performance, ultra low cost calorimeters is a reality. This paper will present some of the design constraints and calibration of a differential thermal analysis (DTA) system for the study of FPE.

RESEARCH AT ENEA: EVOLUTION AND PROGRESS IN MATERIAL SCIENCE FOR STUDYING THE FLEISCHMANN AND PONS EFFECT (FPE)

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Calorimetric experiments have revealed a crucial role of the metallurgy and surface characteristics for reproducing the FPE. A material status to have an improved probability to observe the effect under electrochemical loading of deuterium in palladium has been identified by means of statistical approach. The evolution of the research approach is described in this work.

On the Accuracy of Energetics Technologies Excess Heat Determination

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On April 19, 2009 CBS News Magazine "60 Minutes" profiled Energetics Technologies ("Energetics") in its program "Cold Fusion is Hot Again". In the process of deciding on whether or not to air this program CBS approached more than half a dozen of prominent scientists for their views on the validity of the Energetics reported results of excess heat generation in Experiment number 64. This experiment was selected as a benchmark of the Energetics SuperWave – driven electrolysis experiments as it generated up to 34 watts of excess power when driven with less than 1 watt of input power and gave a total energy gain of approximately 25. These referees raised a number of concerns about the accuracy of, primarily, the Energetics input power determination. In order to respond to these concerns, Energetics performed a series of measurements and analyses related to the accuracy of the input power determination and confirmed the validity of the results it had published. One objective of this paper is to list the concerns expressed by the CBS referees and describe the measurements and analyses Energetics performed in order to address these concerns. Another objective is to describe more recent excess heat generating experiments performed in new electrolysis cells recently designed by Energetics. The new cells are closed and have an internal recombiner whereas all of the previous Energetics experiments, including Experiment # 64, were done in open cells. The closed cell experiments also re-confirm the validity of the Energetics open cell results.

The primary concern raised by the 60 Minutes referees was that excess heat from electrolysis experiments reported by Energetics Technologies (ET) may be due to very high frequency input power spikes due to some kind of "noise", such as an electrical breakdown between the electrodes or that are introduced by the power supply. If the duration of such hypothetical power spikes is a small fraction of the ET data sampling time interval, the ET data analysis will erroneously attribute them to excess heat. Eneretics performed three types of experiments to check the hypothesis of high-frequency noise contamination: (a) increasing the input current and voltage sampling rate from 50 KHz to 500 KHz; (b) analyzing the input current and voltage using a high sensitivity Fluke 199C oscilloscope having a bandwidth of 200 MHz; (c) looking for power spectral correlations between the fluctuations in the output power and the input power. No experimental evidence was found to support the assertion that the excess heat measured in the Energetics electrolysis cells is due to undetected power spikes introduced by electrical breakdown or delivered by the external power supply.

Another concern raised was that the on-line measurement of the palladium cathode electrical resistance may have a significant contribution to the input power that is ignored in the Energetics analysis. Investigation led to the conclusion that the maximum power that can be delivered to the electrolytic cell from the LCR loop used for the cathode resistance measurement circuit is 2.5 mW – four orders of magnitudes smaller than the peak excess heat magnitude.

Also to be described are the new Energetics closed electrolytic cells and their calibration along with excess heat results obtained in these cells.

PROGRESS ON DUAL LASER EXPERIMENTS

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We have continued our experiments using duel laser stimulation of electrochemically loaded PdD_x. In earlier work, we used two properly oriented and polarized tunable diode lasers which provided stimulation at optical frequencies; interestingly, we found that the excess heat is sensitive to the beat difference frequency. Low-level thermal signals are observed to be triggered at apparent resonances when the difference frequency is 8.3, 15.3 and 20.4 THz.

There seems to be a reasonable connection between beat frequencies of 8.3 and 15.3 THz and characteristic frequencies of the optical phonon spectrum in PdD, but the optical phonon spectrum in PdD does not go up to 20.4 THz. However, 20.4 THz is close to a characteristic frequency of PdH, and we believe that our experiments so far have had significant proton contamination. Exploring the role of H contamination in this experiment is a goal of ongoing experiments.

In previous work, we have been limited in the frequency range over which difference frequencies can be generated. In ongoing experiments we have extended the upper limit, and are using the new set-up to see whether resonances occur at higher difference frequencies.

We are also interested in questions concerning the size of the region responsible for the excess heat, as well as the dependence on laser intensity. There is some evidence to support the hypothesis that the excess heat arises from a region larger than the laser spot in our previous single laser experiments. There is also evidence that the excess heat is initiated once the laser reaches a (low) threshold intensity, but that the excess power is relatively insensitive to the laser intensity above threshold.

NEW APPROACHES TO ISOPERIBOLIC CALORIMETRY

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Relative inexpensive isoperibolic calorimeters have been designed and constructed with the goal of obtaining a constant heat transfer coefficient that is insensitive to normal changes in the electrolyte level. The first four prototypes were constructed from copper tubing and used different insulating materials. The outer copper cylinder has a 5.1 cm (2.0 inch) diameter and a 28 cm length. The inner copper cylinder (3.2 cm x 20 cm) is completely separated from the outer cylinder by the insulating material. The glass electrochemical cell (2.5 cm x 20 cm) positioned inside the inner copper cylinder contains 50 mL of electrolyte and has two thermistors positioned on opposite sides of the outer wall of the glass cell. Thermal contact between the glass cell and the inner copper tube is provided by Mobil 1 (5W-30W) motor oil (35 mL) as a heat conducting fluid. This calorimetric design provides for high cell operating temperatures.

Preliminary tests on these prototype calorimeters show excellent stability for the cell temperature measurements (± 0.002¡C), stable heat transfer coefficients during electrolysis, and a precision of ±5 mW (±0.6%) in power measurements up to 800 mW of input power. It is expected that the goal for a precision of ±1 mW or better can be attained with these new approaches to isoperibolic calorimetry. The heat transfer coefficient (k_C) for Cell A is 0.164 W/K, the heat capacity (C_pM) is 450 J/K and the time constant is 40 minutes.

The modeling of these new isoperibolic calorimeters uses the equation $P_{calor} = P_{EI} + P_H + P_X + P_C + P_R + P_{gas} + P_W$ where these power terms have all been defined elsewhere [1,2]. Assuming $P_H + P_X + P_R = 0$ in control experiments, this equation can be rearranged to yield $k_C \Delta T = P_T$ where $P_T = (E\text{-}E_H)I + P_{gas} + P_W - P_{calor}$. For conditions where $(E - E_H)I >> (P_{gas} + P_W - P_{calor})$, then $k_C \Delta T = (E - E_H)I$. For the most accurate results, all of the calorimetric power terms should be included, averaging of the data sets is advised, and numerical integration of the calorimetric differential equation is necessary [1,2].

The first application of these new isoperibolic calorimeter designs is in progress for co-deposition systems. Applications to the study of Pd-B and other alloy materials are also planned. Financial help is acknowledged by M.H.M. from an anonymous fund at the Denver Foundation via Dixie State College.

1. M.H. Miles and M. Fleischmann, “Accuracy of Isoperibolic Calorimetry Used in a Cold Fusion Control Experiment”, in *Low-Energy Nuclear Reactions Sourcebook*, J. Marwan and S.B. Krivit, editors, ACS Symposium Series 998, pp. 153-171, 2008.
2. M.H. Miles and M. Fleischmann, “Isoperibolic Calorimetric Measurements of the Fleishmann-Pons Effect”, ICCF-14, Washington, D.C. August 10 – 15, 2008.

CHARACTERISTICS OF EXCESS HEAT IN $Pd|D_2O+D_2SO_4$ ELECTROLYTIC CELLS MEASURED BY SEEBECK ENVELOPE CALORIMETRY

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We have focused on the reproducibility of excess heat in $Pd|D_2O$ electrolytic cells for some years [1–3]. It was found that excess heats can be reproduced under proper procedure and excess heats occur instantly after electrolyzing for a few hours rather than several days or months. The most important characteristics of excess heat production are following points:

(1) The pretreatment of palladium sample at high temperature is necessary.

(2) Temperature increment during electrolysis is a key factor [2].

(3) Noises of cell voltage decrease when excess heats occur during galvanostatic electrolysis at some time.

Experimental details will be reported in the conference.

[1] W.-S. Zhang, J. Dash, Q. Wang: "Seebeck envelope calorimetry with a $Pd|D_2O+H_2SO_4$ electrolytic cell", Proc. ICCF12, Yokohama, Japan, Nov 27 to Dec 2, 2005, p. 86.
[2] W.-S. Zhang, J. Dash: "Excess heat reproducibility and evidence of anomalous elements after electrolysis in $Pd|D_2O+H_2SO_4$ electrolytic cells", Proc. ICCF13, Dagomys, Sochi, Russia, June 25 to July 1, 2007. p. 202.
[3] W.-S. Zhang, J. Dash, Z.-L. Zhang: "Construction of a Seebeck Envelope Calorimeter and reproducibility of excess heat", Proc. ICCF14, Washington DC, USA, Aug 8 to 10, 2008.

MODELING EXCESS HEAT IN THE FLEISCHMANN-PONS EXPERIMENT

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Over the past several years we have described models based on the linear coupling between two-level systems and an oscillator which are able to convert a large energy quantum into a large number of small energy quantum. At ICCF14 we presented a formula that can be used to calculate the phonon exchange matrix element for a nuclear reaction occurring in a lattice; in this presentation we report on our progress in the brute force computation of the matrix element based on realistic nuclear models. We consider also the development of semiclassical models which can approximate the dynamics of the quantum model. Finally, we describe the use of these models in a numerical simulation of the Fleischmann-Pons experiment. In these models a bottleneck occurs associated with helium diffusion out of the active region. We find that if the active region is thin (100 nm or less) that helium diffusion is fast, and excess heat production can occur in a steady state mode. If the active region is thick (500 nm or greater), then helium diffusion is slow and excess heat in these models occurs in bursts.

Bose-Einstein Condensation Nuclear Fusion: Theoretical Predictions and Experimental Tests

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Theory of Bose-Einstein condensation nuclear fusion (BECNF) [1] has been developed to explain many diverse experimental results of deuteron induced nuclear reactions in metals, observed in electrolysis and gas loading experiments. The theory is based on a single conventional physical concept of "nuclear" Bose-Einstein condensation and provides a consistent theoretical description of the experimental results (both electrolysis and gas loading).

At ambient temperatures, deuterium fusion in metal proceeds via the following reactions:
{4}D(m) + D(m)→p(m) + T(m) + 4.03 MeV (m);
{5} D(m) + D(m)→n(m) + ^{3}He(m) + 3.27 MeV (m); and
{6} D(m) + D(m)→^{4}He(m) + 23.8 MeV (m),
where m represents a host metal lattice/metal particle. Reaction rate R for {6}, R{6}, is dominant.

Experimental observations are summarized below (not complete):
[1] The Coulomb barrier between two deuterons are suppressed
[2] Excess heat production (the amount of excess heat indicates its nuclear origin)
[3] ^{4}He production commensurate with excess heat production, no 23.8 MeV γ ray
[4] Production of hot spots and micro-scale craters on metal surface
[5] Detection of radiations
[6] Production of nuclear ashes with anomalous rates: R{4} << R {6} and R {5} << R{6}
[7] "Heat-after-death"
[8] Requirement of deuteron mobility (D/Pd > ~0.9, electric current, pressure gradient, etc.)
[9] Requirement of deuterium purity (H/D << 1)
[10] More tritium is produced than neutron R(T) >> R(n)

The theory is capable of explaining most of the above diverse experimental observations, and also has predictive powers as expected for a quantitatively predictive physical theory.

The basic concept and important features of the BECNF theory will be presented, and theoretical explanations of the above experimental observations will be described. Key experimental tests of theoretical predictions will be discussed.

[1] Y. E. Kim, "Theory of Bose-Einstein Condensation Mechanism for Deuteron-Induced Nuclear Reactions in Micro/Nano-Scale Metal Grains and Particles", Naturwissenschaften (2009) 96:803-811, DOI 10.1007/s00114-009-0537-6 (14 May 2009) and references therein.

Electron Catalyzed Fusion

A. Huke [1,2], K. Czerski [3,2], G. Ruprecht [4,2], S. Gottlieb [2], L. Martin [4], N. Targosz [3], D. Blauth [5], A. Górska [3], P. Heide [1], and H. Winter [5]

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The investigation of the electron screening effect in nuclear physics and its extension to the model plasma of the electrons in metal hydrides resulted in the finding of the grossly enhanced screening effect for the d+d fusion in metals. Therein the metallic electrons attenuate the repulsive Coulomb barrier of the reacting nucleons which in turn depends on the concrete electronic structure of the crystal lattice of the material. As such it operates analogous to the known myon catalized fusion where the closely orbitting myons strongly screen the Coulomb potential of the nuclei. Thence it constitutes an entrance channel to the d+d reaction in the Cold Fusion phenomenon. This mechanism deigns reason to term it electron catalyzed fusion. Results (including UHV experiments and numerical computations), progress and prospects of this research will be given. Specifically for the investigation of the environmental impact on nuclear reactions the Institut für Festkörper-Kernphysik (Institute for Solid-State Nuclear Physics) has recently been founded.

Anomalous Heat Generation in Charging of Pd Powders with High Density Hydrogen Isotopes (II) Discussions on Experimental Results and Underlying Physics

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Arata-Zhang's excess heat result demonstrated in May 2008 was replicated by more precise works. Using Pd/PdO/ZrO_2 powders (10 nm Pd particle size; produced by Santoku Co., Kobe Japan), we obtained : 1) D-gas charge in the 1st phase (zero pressure interval) gave 20~90 % excess heat than H-gas charge. 2) In the 2nd phase of pressure rise (finally up to 1MPa), significant excess heat (about 2 kJ/g-Pd) for D-gas charge was observed, while near zero level excess heat for H-gas charge was observed.

No increase of neutron counts was seen, nor increase of gamma-ray counts. D/Pd loading ratio in the end of 1st phase was 1.1 in average, and H/Pd ratio was about 1.1 in average. Released energy per D or H-atom in the 1st phase was 2.2-2.5eV or 1.3-2.1eV respectively for D or H. These specific values are anomalously large, compared with known values of 0.5eV and 0.2eV per D or H respectively for surface-adsorption and lattice-absorption of hydrogen gas into bulk Pd metal.

We discuss on the drastic mesoscopic and isotopic effect of surface and lattice rearrangement of nano-Pd particle by full D(H)-absorption to make deeper D(H) trapping potentials of surface adsorption (about 2eV for D). We conclude the anomalously large isotopic and mesoscopic effects in heat generation and D(H) trapping, which will require partially (for the 1st phase) and fully (for the 2nd phase) the explanation by some nuclear reaction mechanisms like our 4D/TSC cluster fusion model. We will report further experimental results by setting higher base-temperature of reaction chamber and changing gas-flow rates.

Ref-1) Y. Sasaki, A. Kitamura, Y. Miyoshi, T. Nohmi, A. Taniike, A.Takahashi, R. Seto, and Y. Fujita: Anomalous Heat Generation in Charging of Pd Powders with High Density Hydrogen Isotopes, (I) Results of absorption experiments using Pd powders, this meeting

ON THE SPATIAL LOCALIZATION OF THE ELECTROMAGNETIC FIELDS IN NON-HOMOGENEOUS MEDIA

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An overview of the conditions for which an electromagnetic field in the optical domain , exhibits strong spatial localization is presented and discussed . Different materials and geometries are presented . Theory and experiments are reported.

The Natural Origin of Excess Heat

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The major focus in the production of excess heat at Energetics Technologies LLC has been experiments using SuperWave^{TM} excitation in electrolytic cells. The successful results of Energetics and the replication by SRI and ENEA have been made possible by a new principle for understanding natural phenomena. This new principle, which I call SuperWaves^{TM}, predicted and is responsible for the generation of excess heat. Historically, from the scientific perspective, attempts to understand the production of excess heat have been in the context of non-life, i.e. from the material and mathematical perspective of the atomic hypothesis. This micro world of quantum mechanics is considered to initiate the fusion of protons and higher Z nuclei believed to exist as discrete objects within the macro scale universe of general relativity and gravity. Coming from the perspective of non-life, these two worlds of different scales remain irreconcilable and often contradictory. In stark contrast, coming from life, the most complex phenomenon we know of, I will present the explanation of excess heat through a new and simple understanding of wave motion as "waves waving." The pattern of SuperWaves is the ultimate commonality of nature that is responsible for its predictable character, explaining how the cyclic metabolism of life is the same as what is perceived as the ubiquitous flux of "energy" in non-life. This universal reality redefines our concept of energy, matter, space and time, and the laws of physics, including the laws of thermodynamics. This is nature's hidden blueprint which mathematicians and physicists have long sought to describe. SuperWave^{TM} reality enables us, for the first time, to explain and access both the inner world of the atom and what lies at the heart of the sun as an inherent continuum. SuperWaves^{TM} is the *natural* origin of excess heat generation and dispersion throughout the universe. This is the true nature of nature.

MASS SPECTROMETRY: CRITICAL ASPECTS RELATED TO THE PARTICLES DETECTION IN THE CONDENSED MATTER NUCLEAR SCIENCE

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Mass spectrometry is one of the most powerful techniques employed in the field of Condensed Matter Nuclear Science to investigate experimental processes that involve electrochemical loading of metals with deuterium.

The large interest of this technique comes from the assumption that the excess of power produced in these processes could be explained in terms of nuclear reactions giving particles plus energy as final products. Since many years ago, the attention has been focused on ^{4}He coming from the reaction D+D = ^{4}He + heat (24 MeV for event) in the palladium lattice. On the basis of the produced heat excess, the amount of the predicted helium particles is very small compared to the sensitivity of the standard instruments. Therefore high performance mass spectrometer is required for this measurement and to discriminate D_2 from ^{4}He that are very close in atomic masses.

Another field of interest refers to metallic thin films electrochemically loaded of hydrogen. Evidence of nuclear processes should be revealed from the possible deviation of isotopic composition on the film surface. Also in this case, high performance mass spectrometer in SIMS (Secondary Ions Mass Spectrometry) configuration is required and very accurate procedures must be followed to exclude surface contamination or other spurious effects on the measurement.

In this presentation a review of the mass spectrometry characteristics will be given together with some considerations on the requirements for the experimental apparatus.

Search for Nuclear Reaction Products in Gas Phase Experiments - Deuterium Permeation and Absorption -

A. Kitamura[1], Y. Sasaki[1], Y. Miyoshi[1], Y. Yamaguchi[1], A. Taniike[1], Y. Furuyama[1], A. Takahashi[2], R. Seto[2], and Y. Fujita[2]

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Employing both *in situ* and *ex situ* accelerator analyses, we have tried to replicate the nuclear transmutation [1] of Sr to Mo under deuterium permeation through a variety of multilayered CaO/Sr/Pd samples. Apparently positive results have been obtained in 8 runs out of 14, although the identification of Mo peaks in the PIXE analysis are not definite. It is implied that sputtering loss of the atoms could be responsible for the observed tendency that areal density of Sr decreases in most cases, while there is a modest increase in Mo. In addition to the accelerator analyses, γ-ray detection is tried for samples implanted with W atoms in expectation of transmutation from ^{183}W to radioactive ^{191}Pt.

As another series of experiments, we intended to confirm heat and ^{4}He generation by deuterium (D) absorption in nano-sized Pd powders reported by Arata and Zhang [2], and to investigate the underlying physics. The experimental procedure and the results on the heat measurements will be discussed in detail in the following two presentations [3,4]. As will be explained there, nano-sized powder of mixed Pd and Zr oxides fabricated by Santoku Corp., Kobe, Japan, have revealed not only interesting mesoscopic effects but also large isotope effects both in the first phase (zero-pressure interval) and the second phase (with the pressure increasing up to the stationary value) of gas filling.

In the latter half of the present paper, we discuss a possible cause of the large isotope effects mentioned above. For this purpose, detection of possible nuclear ash including charged particles as well as neutrons and gamma rays are tried.

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[4] A. Takahashi, A. Kitamura, Y. Sasaki, Y. Miyoshi, T. Nohmi, A. Taniike, R. Seto, and Y. Fujita: Anomalous Heat Generation in Charging of Pd Powders with High Density Hydrogen Isotopes, (II) Discussions on Experimental Results and Underlying Physics, this meeting.

ABOUT PRODUCTS OF NUCLEUS REACTIONS DURING DIFFUSION OF DEUTERIUM THROUGH PALLADIUM MEMBRANE.

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The present manuscript deals with experimental testing (examination) of the earlier proposed mechanism of low energy nucleus reaction (LENR) [1,2] in a metallic matrix.

The experimental device comprises a metallic chamber with a system for heating. A cylinder with a fixed membrane is installed inside this heating system. For processing a required structure the membrane has been subjected to thermo-mechanical treatment.

The manuscript considers the results of measurement of helium (IV) and tritium concentration as well as metallographic studies of a membrane surface.

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IMPURITY MEASUREMENTS BY INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS ON PALLADIUM, NICKEL AND COPPER THIN FILMS

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In the last decades scientific papers [1-3] have been published on both nuclear transmutation reactions in condensed matter and relative analysis performed by Instrumental Neutron Activation Analysis (INAA) for verifying the nuclei formation during the experiments.

In this contest, a specific research activity has been developed at the Research Centers (Casaccia and Frascati) of ENEA: different experiments were set up for verifying and testing the data present in literature [2,3].

Each step of the procedure reported in [2,3] has been analyzed and deeply investigated: the materials such as electrolysis equipments, electrolytic solutions, electrodes, etc. were preliminarily analyzed by INAA for identifying and reducing all the pollution sources.
Successively, different experiments [4] were performed using films of palladium, nickel and copper as electrodes. At the end of each test, all the materials and the electrolytic solutions used and the blank as well, were analyzed by INAA for checking and measuring the presence of nuclei originating from nuclear transmutations.

INAA is in fact able to determine element content at a very low level, where other analytical techniques cannot reach with such precision and accuracy.

A particular effort has been carried out to identify the conditions for false positive signals.

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ANALYSIS OF PERMEATION INDUCED TRANSMUTATION FROM THE ASPECTS OF DEUTERIUM DENSITY AND ELECTRONIC STRUCTURE IN PD MULTILAYER FILM (PD/CAO/PD)

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Nuclear transmutation reactions induced by D_2 gas permeation through Pd multilayer complexes (Pd/CaO/Pd) were firstly reported in 2002 by the author's team [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" measurement using x-ray fluorescence spectrometry (XRF) at SPring-8. Transmutation reactions seem to occur at localized spot near surface within 100nm under our experimental conditions. 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 $^1H(^{15}N, \alpha\gamma)^{12}C$, 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 are now trying to measure deuterium density near surface in Pd multilayer thin film during permeation since we postulate that it is important factor for inducing transmutation reactions.

Recently, we have started first principal calculation for this phenomenon based on the assumption that a characteristic electronic structure might be found for transmuted elements. Electronic structures of atoms put at the center of Pd cuboctahedron cluster are studied theoretically using a density-functional scheme. The atom before transmutaion (Cs, etc.) is modelled with hydrogen atoms and the atom after transmutation (Pr, etc.) is modelled without hydrogen. Similarity and the difference in the electronic structures for those atoms is now examined.

Results of these recent measurement and calculation will be presented at the conference.

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EVALUATION OF THE CLAIM OF TRANSMUTATION OF CESIUM TO PRASEODYMIUM WITH THE MHI STRUCTURE

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The MHI claim to transmute elements upon permeation of deuterium though a specific multilayer structure was carefully evaluated. Initially, an attempt was made to replicate the work at NRL in collaboration with MHI. When replication proved difficult, another set of experiments were conducted at MHI in three sets consisting of two control blanks and one positive foil (that should have transmuted Cesium to Praseodymium) per set. Foil samples were split for analysis at both NRL and MHI. Extensive analytical work was performed to characterize the foils and the blanks. When extracted at MHI, low nanogram amounts of Pr were found by ICP-MS on 3 of 3 foils that should have had Pr whereas the 6 controls were blank. Split solutions of these extracts were also tested independently at NRL and the presence of Pr was confirmed. The Pr found did not have the characteristic rare earth contamination expected if the Pr was from the environment and thus looked like it was produced in the experiment. Unfortunately, we could not find Pr at NRL (even at trace levels) on our split foil samples no matter what extraction method was employed. After considering and evaluating several unlikely scenarios for these disparate results, we visited MHI and participated in the extraction process on new foils. These extracts were blank when tested at both laboratories. Environmental samples were obtained at various locations where samples were handled. Pr was found in large amounts at one location used in sample preparation and this Pr had the signature of pure material rather than an inadvertent contaminate. No record of how it got there could be established. Other rare and characteristic impurities also were found in the extracts from MHI that were present in the laboratory environment. Thus, we concluded that the transmutation of Cs to Pr when deuterium permeated MHI's multilayer structure could not be firmly established, as contamination during the foil production or during the foil analysis could not be ruled-out. The design of the replication experiments, the lessons learned, and the results will be discussed.

PRODUCTION OF HELIUM AND ENERGY IN THE "SOLID FUSION"

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In this paper, A new type "Solid Fusion Reactor" has been developed to test the existence of solid state nuclear fusion (" Solid Fusion"): reproducible experiments have been made at room temperature and without external power input. Both of the energy and Helium generation affected by the reactor structure, gas flow rate, powder weight, and cooling condition were studied. Deuterium gas loading processes of two types of nanomaterial (ZrO_2 · Pd_{35} and ZrO_2 · $Ni_{30}Pd_5$) were studied respectively in this paper. The results showed the energy produced in ZrO_2 · $Ni_{30}Pd_5$ is higher than in ZrO_2 · Pd_{35}. Helium as an important evidence of solid-state fusion was detected by mass analyzer "QMS". As result, " Solid Fusion" has been confirmed by the helium existence, and then we developed the Helium production system.

LOW TEMPERATURE GAS LOADING OF DEUTERIUM IN PALLADIUM

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ABSTRACT

One of the most established features of the phenomenon known with the name of "Cold Fusion", with reference to the system palladium (Pd) – deuterium (D), is that a condition necessary (even though not sufficient) to be satisfied in order for these phenomena to take place is that the content of D in Pd, called also the D/Pd ratio X, approach the value of 1 (intending by this quantity the atomic ratio between the two species in the Pd lattice). In order to reach such an high value of X, extensive use of electrolysis of heavy water with a Pd cathode has been made.

This experiment is aimed at obtaining high loading ratios of deuterium in palladium without using electrolysis. The idea is to have deuterium gas in contact with palladium. The use of low temperatures has the purpose of increasing the equilibrium loading ratio for a given gas pressure.

A first test experiment, performed at ENEA Frascati in 2002, showed that it was possible to have D/Pd ratios as high as 1 at 150 K with a pressure lower than 1 bar[1]. The experiment has been rebuilt at LNF/INFN and hopefully the first results will be reported.

An anomaly in the process of charging will be also reported.

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Towards a high temperature CMNS reactor: nano-coated Pd wires with D_2 at high pressures. Identification of main control parameters, development of simple tests about quality of coating.

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Since ICCF14 Conference, held at Washington D.C. on August 2008, we developed an innovative procedure in order to improve the anomalous excess heat coming out from the interaction of gaseous pressurized (2-8 Atm.) Deuterium with Palladium, especially in the high temperature regions (200-500°C).
The method was based on the *controlled* coating of, Pd-based, nanomaterials on thin (diameter 50μm) and long (l=60-70cm) Pd wires. The amount of coating thickness was in the range of 1-3μm.
The maximum excess power detected was over 5W, lasting several hours and without apparent reduction over time. The input power, because large pressurised SS cell adopted (volume about 3 litres) and the wall kept at 25-30°C by large water bath, was of the order of 50W. At such input power, by DC current fed to the Pd wire (and to a similar Pt wire used as internal calibrator), the estimated temperature of Pd wire was about 450°C. The large temperature drop (and large power needed), arises because very large thermal conductivity of Deuterium gas. Moreover, calibrations were made using ^{4}He gas at similar pressures.
Since that time, we tried, at Frascati National Laboratory of National Institute of Nuclear Physics, to improve the over-all efficiency by reduction of the cell volume (from 3000 to about 100cm^3). In such a way, to keep the Pd wire temperature at the proper temperature where the anomalous effects start, it was necessary to thermally insulate the SS cell. As a consequence, the *internal* SS wall temperature, from 25°C, reached values of the order of 250-400°C. Unfortunately, at such high temperatures, there was an unacceptable degassing of the components of the SS (Fe, Ni, Cr, C, S, P). The most dangerous was S, usually present in large quantity in almost any kind of

Continued

SS (AISI 304, 316LN). It is well known that the Sulfur as very adverse behaviour to catalytic propriety of Pd.
Because the technical solution to overcome such problem takes long operation time, we decided to use again the “old” big SS cell in order to study, in deeper details, the behaviour of our system in respect to “aging effects” (at almost constant operation temperature/power) and “stress condition” (at quite high power levels for short time, from seconds to minutes).
In conclusion, we found a procedure that can be, in principle, the starting point of a CMNS high temperature engine.
Moreover, we found a very simple procedure that allows the changing of geometrical dimension of Pd wire even operating at peak temperatures as low as 300°C. As example, in only 3 hours of operations, we were able to get a reduction of 500% of Pd length and a diameter increase of (about) factor 2-2.2.
Some of the key procedures/results are under patent.

WAVE NATURE OF DEUTERIUM FLUX PERMEATING THROUGH PALLADIUM THIN FILM WITH NANOMETER COATING LAYERS --- (II) THEORETICAL MODELING

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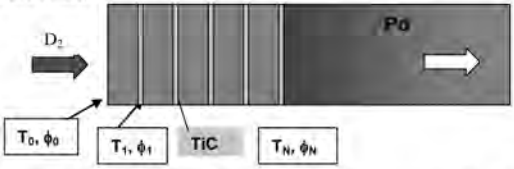
Super-wave has generated the long lasting, high gain "excess heat" in deuterium/palladium systems during Energetics Technologies, ENEA, and SRI collaboration. There must be an internal wave nature of the deuterium/palladium systems, which is in response to external super-wave, particularly, near the surface of the deuterium/palladium systems. Three sets of experimental data in the past 7 years at Tsinghua University are summarized to reveal this wave nature (please see abstract (I)). A simple theoretical model was set-up to understand this wave nature.



In the picture each interface is described by two parameters, the transmission rate (T), and the change of the phase angle (ϕ). Based on the matrix algebra, we may reach 3 conclusions:

(1) The tansmission rate of the palladium coated with nanometer TiC-Pd layers is

$$T_N = \left| \frac{Sin\alpha_1}{\sqrt{\frac{1}{T_1}} e^{i\phi_1} Sin(N\alpha_1) - Sin[(N-1)\alpha_1]} \right|^2$$

$$\phi_N = Arg[(\sqrt{\frac{1}{T_1}} e^{i\phi_1} Sin(N\alpha_1) - Sin[(N-1)\alpha_1])/Sin\alpha_1]; \qquad \alpha_1 = ArcCos[\sqrt{\frac{1}{T_1}} Cos\phi_1]$$

Here, N is the number of nanometer coating layers. Using 4 input parameters, T_0, ϕ_0, T_1, ϕ_1, it reproduces the experimental data. Here (T_0, ϕ_0) describes the interface between deuterium and palladium. (T_1, ϕ_1) describes the interface of Pd-TiC-Pd.

(2) An identity is derived to show the correlation between deuterium flux and the "excess heat " :

$$\frac{A_{0N}}{T_{0N}} = \frac{A_0}{T_0} + \frac{A_N}{T_N} + \frac{A_0}{T_0} * \frac{A_N}{T_N}.$$

Here, (A_0) describes the absorption in the interface between deuterium and palladium, and (A_N) describes the absorption in the N-Layers of Pd-TiC-Pd coating. (A_{0N}) describes the absorption in the combination of the interface between deuterium and palladium and the N-Layers of Pd-TiC-Pd coating. This identity shows the effect of multiple scattering among those interfaces.

(3) Super-wave may affect the surface parameters ϕ_0, ϕ_1 ; then, it changes the deuterium flux which permeating through the palladium film with multiple coating layers, T_{0N} . Thus it will enhance the "excess heat" (A_{0N}).

THERMODYNAMICS OF Pd/H SYSTEM UNDER COLD H_2 PLASMAS

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The absorption of hydrogen by Pd wire samples has been studied at 299 K in the α+β and β regions and in the H_2 pressure range from 18 to 1800 mbar under tensile stress under with and without cold H_2 plasma.

Plasma is generated in a corona discharge regime by applying a dc high voltage between a Pd wire and a cylindrical counter-electrode. Positive and negative coronas have been performed.

Three independent experimental quantities have been simultaneously measured: ratio $x=n_H/n_{Pd}$, with n the number of atoms; ratio R/R_0, with R the four-probe resistance of the wire and R_0 the resistance when $x=0$; and ratio $\Delta l / l_0$, with Δl the length change of the wire and l_0 its length when $x=0$.

From the thermodynamic analysis of data, the absorption standard chemical potential, $\Delta\mu^{\circ}_{abs}$, and the excess chemical potential, $\Delta\mu^{exc}$, of hydrogen atoms in Pd have been obtained. At constant T, H_2 pressure, and tensile stress, the x value under cold plasma is always higher. An increase in the above quantities was always observed when plasma was lighted. The ability of an external electric field produced by the corona discharge to perturb the thermodynamic state of the Pd/H system was experimentally demonstrated.

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Does Gas Loading Produce Anomalous Heat?

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Simple pressurization of nanosized palladium with deuterium appears to be a simpler and more rapid method to generate anomalous heat compared to electrolytic systems. A survey of the literature indicates that palladium particles less than 2 nm in size can obtain a Pd/D loading near one at modest deuterium pressure. In hundreds of reactions, we have routinely prepared palladium nanoparticles inside an aluminosilicate matrix and have found that these systems produce up to 8 fold more heat with deuterium compared to hydrogen. Furthermore, a characteristic signature of a pressurization reaction is its reversibility - the heat released upon pressurization should be absorbed upon evacuation. This reversibility is observed with hydrogen but not deuterium. Although we are still seeking conventional explanations for this excess heat, the anomalous heat does not appear to be explained by impurities in the deuterium gas nor other simple chemical or physical sources. The selection and preparation of the particles, the experimental set-up, and results will be discussed.

Low Energy Nuclear Reactions in Condensed Matter Environment Enhanced by a Deuterium Desorption

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Many efforts have been directed since March 1989 to convince physicists in reality of nuclear reactions in condensed matter environment. Despite numerical observations of excess heat events accompanied by He-4 and tritium generation (though in atomic form, not as nuclear particles), the electrochemical experiments of Fleischmann-Ponce type do not show direct nuclear signatures. The only large magnitude of specific heat demonstrating in calorimetric experiments (of the orders of keV/Pd atom) may not be enough to convince in nuclear origin of the excess heat. On the other hand, the changes in stable isotope ratios observed in the "transmutation" experiments do not accompany by nuclear emissions and massive X-ray radiation. This is why, a real proof of, at least, conventional DD-reaction enhancement by condensed matter environment in metal deuterides are of great importance.
Here we present a review of nuclear evidence obtained in experiments involving metal deuterides possessing simultaneously by high deuterium solubility and enhanced D-desorption rate:

-DD-reaction enhancement during low energy deuteron bombardment of metallic targets (accelerator and glow discharge experiments).
-Low intensity emissions of DD-reaction products during from metal cathodes after D-loading: 3 MeV protons, 1 MeV tritons, 2.45 MeV neutrons.
-Energetic alphas (E ≥ 9 MeV).
-Soft X-ray (Ex ≤1.5 keV) emission from metal cathodes in pulsed Glow Discharge and D-desorption experiments.

The presented data on observation of real nuclear signatures accompanying deuterium loadin/deloading in metals, open the way to convince physicists in nuclear origin of excess heat effect. To this goal the following approaches are desired:

- To perform complete experiment with simultaneous detection of excess heat, atomic ^{4}He, ^{3}T, charged particles (DD-products +energetic alphas) and neutron emissions, as well as soft X-rays (Ex ≤ 2.0 keV), not characteristic K_α of Pd)
- To search for correlations between excess heat events and emissions of atomic, nuclear species and X-rays
- To employ special electrolytic cells and appropriate state-of- the-art calorimetric and nuclear detection equipment.
- To use (nanostructured/nanolayered) highly D-loaded cathode samples (Pd-SWCNT-Pd, Pd-Re-Pd and PdO-Pd-PdO) with both enhanced deuterium desorption flux and DD-reaction yield.

EFFECTIVE POTENTIAL FOR DEUTERON-NUCLEUS COLLISION IN METALS

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It was found from deuteron beam experiments that screening potential for the D+D reaction in metal shows very large values up to 300 eV [1-3]: this causes enhanced reaction rates at energies far below the Coulomb barrier. However, the origin of the large screening is not understood well. If the screening due to dense electrons in a metal is a main contribution, the similar large screening effect would be expected also for the collisions between a deuteron and a host metal nucleus.

In these several years we have accumulated precise data of the D(d,p)t reaction in various metals (Z from 4 to 79) with bombarding energies between 10 and 20 keV. It is found that a yield ratio of protons to tritons measured at a fixed angle contains important information on deuteron-nucleus effective interaction in metals, which is difficult to deduce for such low bombarding energy.

In the present work, we show the results of these measurements and discuss on effective deuteron-nucleus interactions in various metals. It is concluded that although calculations using the Universal potential reproduce the trend of the experimental data, the observed p/t yield ratios cannot be fully explained. In order to obtain better agreement, an effective potential with a shorter screening length is required. The screening potential for the D+D reaction in metal is also discussed.

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Enhanced Electron Screening and Nuclear Mechanism of Cold Fusion

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The enhanced electron screening effect observed in accelerator experiments for the $^{2}H(d,p)^{3}H$ and $^{2}H(d,n)^{3}He$ reaction in deuterized metallic targets can increase the fusion reaction rates at room temperature by a factor of 10^{40} compared to the value predicted for the deuterium molecule. However, the domination of ^{4}He production observed in cold fusion experiments requires a 0^{+} resonance which should exist in the compound nucleus ^{4}He very close to the D-D reaction threshold. Theoretical and experimental arguments for such a resonance, its spectroscopic structure and decay modes will be discussed in detail. The interplay between the electron screening effect and the resonant fusion reaction mechanism at room temperature offers a simple explanation of heavy-water electrolysis experiments, which will be illustrated by new theoretical calculations. Importance of proposed effects can also be studied in radioactive decays taking place in different hosting materials. The predicted increase of the decay constant of alpha decays in metallic environments agrees very well with results of the first experiments.

Li + D FUSION ASSISTED WITH ACOUSTIC CAVITATION

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It has been revealed that a dynamic mobility of deuteron is an essential factor to induce condensed matter nuclear effect rather than a high deuteron density. Various efforts have been made to establish and enhance the effects by realizing such unusual conditions: one of them is to provide a field with acoustic cavitation bubbles.[1-3]

In beam experiments, we have reported ^{7}Li+p and ^{6}Li+d fusion reactions with liquid lithium target, in which ionic Debye screening caused by liquefied Li^{+} ion enhances the reaction rates. [4] In this work we introduce an ultra sonic wave into the liquid Li target, in order to investigate cavitation effects on the reaction rate.

A bolt clamped langevin type transducer is connected to a SUS316L target holder via an aluminum horn which passes a sonic wave through a wall of a vacuum chamber: a position of the wall is adjusted so as to correspond with a node of a generated longitudinal wave. This system can generate vibrations with amplitude from 1 to 10 μm at the surface of the lithium target with its resonance frequency of 18.8 kHz. When the amplitude exceeds a threshold value (typically 2.5 μm) countless acoustic cavitation bubbles are observed on the liquid lithium surface. Typical experimental conditions are as follows: temperature of liquid lithium is ~240 ^{o}C, pressure in the chamber is ~10^{-4} Pa much above the vapor pressure of the lithium, and the target is enriched ^{6}Li (95 at%).

We have bombarded the lithium bubble target by deuteron beams with the incident energy between 10 to 80 keV. Emitted α particles from the ^{6}Li(d, α)α reaction and protons from the d(d, p)t reaction were detected by a Si SSD, and energy and time information of each event were recorded. Preliminary measurements and analyses so far performed show clearly that the reaction rate varies in cycles which synchronize with the frequency of the ultra sonic wave, although the enhancement of the reaction rate is not so large. At present, we conjecture that high lithium density at the timing of the bubble collapse induces the high reaction rate.

We will present, in detail, the experimental system of liquid target with the ultra sonic wave and discuss the observed time correlation of the nuclear reaction rate to the frequency of the ultra sonic wave.

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LITHIUM FLUORIDE X-RAY IMAGING FILM DETECTORS FOR CONDENSED MATTER NUCLEAR MEASUREMENTS

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Lithium Fluoride, LiF, is a radiation sensitive alkali halide material well known as dosimeter and as active medium in light-emitting devices and lasers. Point defects can be produced in LiF crystals and films [1] by different kinds of radiation. Some of these electronic defects, known as colour centres, are optically active, with broad absorption and emission bands in the visible spectral range. Novel thin-film imaging detectors for soft X-rays, based on photoluminescence from aggregate colour centres in LiF, have been proposed [2] and are currently under development [3], successfully extending their operation also in the hard X-ray region, up to 10 keV [4]. Recently their use was proposed and preliminarily tested to obtain the image of radiation emitted from a nickel film hydride loaded by electrolysis, under light coupling with an He-Ne laser [5]. Among the main peculiarities of LiF-film based X-ray imaging detectors, there are an intrinsic high spatial resolution, a large field of view and a wide dynamic range. Moreover, they are easy to handle, as insensitive to visible light and no development process is needed. After exposure to X-rays, the latent images stored in the LiF thin layers are read by advanced optical fluorescence microscopes, with typical spatial resolution below 300nm. These detectors can be applied in photonics, biology, material science, and in the characterization of intense X-ray sources. They allow great versatility, as they can be grown in the form of thin films by well-assessed physical deposition techniques.

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Neutron Detection: Principles, Methods, Issues (and Tips)

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The production and detection of neutrons in the so called "cold fusion" phenomena is claimed since the first announcement by Fleischmann and Pons in 1989. In the last twenty years the same claim has been made by other authors despite they were operating under different experimental conditions. However, most of the scientific community is yet sceptic about the actual emission of neutrons from events that in a more general statement are known as "low energy nuclear reactions in condensed matter " (CMNS).

The question whether neutrons are actually produced in low energy nuclear reactions in condensed matter phenomena is still open because the methods and the procedures adopted as well as the results claimed by the various authors are often subjected to several criticisms. Indeed the subject of CMNS is rather complex and relates with several different subjects so synergy among the various subjects is necessary. Among these subjects, neutron detections requires a particular care and expertise because the measurements are carried out with a very low signal to noise ratio.

In this paper a very brief review of the main physical laws and basic detection principles for neutrons are addressed. The main issues to be faced when measuring pulsed "neutron emission", as claimed in most experiments, are addressed too.

It is not in the author's intention to investigate whether or not neutrons are actually emitted in CMNS phenomena, however, an "ideal" experiment that could allow to unambiguous measurement of neutrons from a CMNS type experiment will be outlined.

INVESTIGATION OF ANOMALOUS DENSITIES OF HIGH–ENERGY ALPHA–PARTICLES TRACKS IN CR-39 DETECTORS DURING ELECTROLYSIS OF HEAVY WATER ON PALLADIUM CATHODES

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Recently, several researchers claim the finding of anomalous alpha-particles generation during very simple electrolysis experiments with heavy water and palladium cathodes. The phenomenon seems to improve if deuterium formation on the cathode is associated with deposition of palladium nanostructures coming from chlorides of the same metal present in the electrolytic solution. Due to the relevance of the claims and considered the simplicity of the experimental apparatus, several tests have been performed in order to confirm the claimed results. The results of these tests will be the object of this scientific report.

HOT SPOTS, CHAIN EVENTS & MICRONUCLEAR EXPLOSIONS

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It is now generally accepted that LENR type nuclear reactions primarily take place on the surface (or in the near surface region) rather than in the bulk metal. Most researchers also subscribe to the notion that there is a special environment christened as "Nuclear Active Environment" or NAE by Ed Storms where various nuclear reactions appear to be taking place. What however is not spelt out clearly but seems to be commonly believed is that these NAEs are not created at the same instant throughout the surface region of the host metal but possibly produced in localized regions or hot spots during the dynamic diffusion of deuterons in and out of the metal or during any other type of triggering mechanism. Also it is unlikely that once a NAE is formed it is going to continuously catalyze nuclear reactions for all time to come. Thus the active life time of an NAE is of interest: Does it last for nano secs, microsecs, minutes or hours? The nature of the NAE continues to be elusive.

At ICCF 1 and later at Provo (both meetings held in 1990) the BARC group first presented results based on their tritium and neutron measurements, especially the multiplicity distribution of neutron output, that suggested that micro nuclear explosions seem to be taking place at localized hot spots which generate both Tritium and neutrons (subject to the n/T branching ratio anomaly) in Ti targets. The rationale for arriving at the micronuclear explosion hypothesis has been re-presented by this author in a comprehensive review paper included in the forthcoming ACS LENR Sourcebook Vol 2 (2009) Edited by Jan Marwan and Steven Krivit. We have estimated that about 10^{12} to 10^{14} LENR reactions take place highly localized in space and time.

Since the 90s many other researchers (notably Mitch Swartz, Pam Boss) have reported observing hot spots in their excess heat producing cathodes, Although these authors themselves have not claimed that these hot spots could be due to nuclear reactions, it is tempting to speculate that perhaps the concept of micronuclear explosions is applicable to heat generating helium producing reactions too. One can easily estimate for a hot spot to be detected, how many nuclear reactions should take place at a given spot in a very small time duration?

On the theoretical side, many models especially those which depend on the catalyzing role of some exotic particle (Erzions, poly neutrons, trapped neutrons etc) also seem to point to the possibility of occurrence of chain events. In any case two decades into CMNS it may be worthwhile examining the merits of the micronuclear explosion hypothesis and seek experimental evidence to either rule it out or have it confirmed.

Discovery of Erzion Nuclear Reactions Tracks (Pits) in Plastic Solid-State Detectors, Exposed in Space

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Oriani & SPAWAR results in CR-39 films and their interpretation in framework of Erzion model had initiated research of such effect in space. Already about 40 years such solid-state detector film piles were used in a free space on the satellite orbit for nuclei fluxes studying. The first result was grandiose. The pit density was rather more then order grater then its background on the sea level. For an explanation of such intensive cover of the films surfaces of solid-state detector film piles by pits (tracks with special pit form & small depth) after their exposition in a free space on the satellite orbit there has been offered such mechanism of nuclear interaction of neutral cosmic ray Erzions [1,2]. In framework of Erzion model low energy neutral Erzion (E~10keV), coming into organic film substance, due to catalytic cyclic nuclear exchange reactions creates the big quantity (~10^6) of recoil nuclei (H^3, C^{12}, C^{14}, N^{15}…) with energy 0.1-5 MeV.

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. All this researches have confirmed the truth of the Erzion hypothesis [3-5]. The opportunity to give other, simpler explanation of the received results was not found. More over, it has been discovered the tracks of stopping negative charged cosmic Erzions in solid-state detector film pile, finished by pits swarm. 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 of the put forward hypothesis.

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COMPARISON BETWEEN PIEZONUCLEAR REACTIONS AND CMNS PHENOMENOLOGY

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Piezonuclear reactions have been theoretically foreseen and studied in the framework of a theory that deals with Local Lorentz Invariance (LLI) breakdown by introducing a microscopically deformed space-time [1]. According to this theory, new types of nuclear reactions can be induced also in stable medium-weight or heavy nuclides. The condition for these processes to take place is the release of an amount of energy to the nuclear system higher than an energy threshold of 367.5 GeV in a suitable interval of time. Some details of the theory will be briefly presented. The phenomenological mechanism that we used in our experiments in order to fulfil these two requirements is cavitation and more precisely bubble collapse brought about by ultrasounds [2]. It is necessary to point out that our theoretical, phenomenological and experimental research has nothing to do with sonofusion [3]. We cavitated solutions of different concentration of Iron wherefrom we obtained neutron bursts. Three different techniques were used to detect them: bubble detectors, CR39 screened by Boron and Boron Trifluoride. All of these techniques provided compatible results. The difference between neutron signal and the background-noise was more than 13 standard deviations [5]. Moreover, Boron screened CR39 were irradiated by neutrons from a nuclear reactor in order to produce tracks on CR39 plates able to provide a clear term of comparison. The tracks on CR39 irradiated during experiments of piezonuclear reactions are compatible with the former with some slight distinction which will require further investigation. Other evidences from these experiments are the lack of gamma rays, that are usually concomitant with neutrons, the existence of a threshold in time for neutrons to be emitted and the presence of Iron as key nuclide [4,5]. As to the lack of gamma rays, however, more extensive and refined investigations will have to be carried out since, although the theory, on which piezonuclear reactions are based, can explain (so far only qualitatively) the absence of concomitant gamma rays with emitted neutrons, prompt gamma rays produced by the interaction of neutrons with the surrounding medium (water) are indeed expected to be present. Besides, several evidences of transmutations during cavitation of water were obtained as well, but we shall not comment on them [6,7,8]. We will carry out a mere comparison of these "anomalous" results with those "anomalous" alike found in LENR-CMNS experiments. Finally, on the basis of such a comparison, we shall briefly wonder whether this alikeness of mere experimental results, obtained by so different experimental setups, might hide some common microscopic mechanisms in such unlike apparatuses and experimental procedures. The hypothesis will be put forward that the two conditions mentioned above as the key features of piezonuclear reactions might take place in LENR-CMNS experiments as well and might contribute to generate what is commonly referred to as nuclear active environment (NAE).

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PIEZONUCLEAR REACTIONS IN INERT SOLIDS: NEUTRON EMISSIONS FROM BRITTLE FRACTURE

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The results of the present paper are in strict connection with those presented in a previous contribution recently published in Physics Letters A [1] and related to piezonuclear reactions occurring in stable iron nuclides contained in aqueous solutions of iron chloride or nitrate. In the present case, we consider a solid containing iron –samples of granite rocks– and the pressure waves in the medium are provoked by particularly brittle fracture events in compression. As ultrasounds induce cavitation in the liquids and then bubble implosion accompanied by the formation of a high-density fluid or plasma, so shock waves due to compression rupture induce a particularly sharp strain localization in the solids and then material interpenetration accompanied by an analogous formation of a high-density fluid or plasma.

Our experiment follows a different path with respect to those of other research teams, where only fissionable or light elements (deuterium) were used, in pressurized gaseous media [2], in fluids with ultrasounds and cavitation [3], as well as in solids with shock waves and fracture [4]. We are treating with inert, stable and non-radioactive elements at the beginning of the experiments (iron) [5], as well as after the experiments (aluminum). Neither radioactive wastes, nor electromagnetic emissions were recorded, but only fast neutron emissions.

Therefore, our conjecture is that the following piezonuclear fission reaction should have occurred in the compression tests on granite specimens [5]:

$$^{56}Fe \rightarrow 2\ ^{27}Al + 2n$$

The present natural abundance of aluminum (7-8% in the Earth crust), which is less favoured than iron from a nuclear point of view (it has a lower bond energy per nucleon), is possibly due to the above piezonuclear fission reaction. This reaction –less infrequent than we could think– would be activated where the environment conditions (pressure and temperature) are particularly severe, and mechanical phenomena of fracture, crushing, fragmentation, comminution, erosion, friction, etc., may occur. If we consider the evolution of the percentages of the most abundant elements in the Earth crust during the last 3 billion years, we realize that iron and nickel have drastically diminished, whereas aluminum, silicon and magnesium have as much increased. It is also interesting to realize that such increases have developed mainly in the tectonic regions, where frictional phenomena between the continental plates occurred.

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X-RAY SPECTRA OF EXCITED LONG LIVING 0.6 – 6.0 keV ENERGY LEVELS FROM THE SOLID STATE CATHODES OF ELECTRIC DISCHARGE SYSTEM

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The experiments were carried out using a pulsed high-current glow discharge device, consisting of a water-cooling vacuum chamber, water-cooling cathode and anode units [1]. The X-ray emission has been recorded through a diagnostic window placed above the cathode. The discharge was initiated in H_2, D_2, Ar, Kr and Xe gas atmospheres at pressure in the range of 1 – 5 Torr using cathode foils of Al, Sc, Ti, Ni, Mo, Pd, Ta, W. The discharge current up to 200 mA, corresponding to voltages in the range of 3000-4300 V has been applied. The glow discharge was operated with specially designed pulse-periodic power supply [1]. The fine structure of X-ray spectra were detected using a bent mica crystal X-ray spectrometer and recorded on X-ray film.

The X-ray spectra were obtained both as the continuum bands with energies ranging from 0.6 to 10.0 keV, as well as in the form of spots caused by emission 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 discharge current switching off (during up to 20 hours afterwards). The X-ray emission energy bands were found to be correlated with the K – L and the L – N X-ray transitions. The X-ray spectra include the following bands: K – M_3 X-ray transitions of 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 and in case of the high intensity beam emission they turned into white color spots (due to solarization of the photoemulsion). The "solarization" is normally characterized a large density of X-ray irradiation of X-ray film or negative photographic material. The energy of the spots depends on the material of cathode sample. Note that all obtained experimental results showed 100% reproducibility.

In our opinion, these results represent direct experimental evidence of the excited metastable energy levels of 0.6-10.0 keV in solid state cathode material.

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Concentration polarization in hydrogen permeation through self-supported Pd-based membranes

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Concentration polarization present in any membrane separation affects the system performance depending on the membrane permeance, i.e., a higher permeance leads to a higher polarization. Hydrogen transport in Pd-based supported membranes was described by means of a model [1] considering several elementary steps of the permeation process, improving what done by Ward and Dao for self-supported membranes. The model includes the external mass transfer in the multicomponent gaseous phases on both membrane sides, described by the Stefan-Maxwell equations. The transport of the multicomponent mixture in the multilayered porous support was also considered and described by means of the Dusty Gas Model, which takes into account Knudsen, Poiseuille and ordinary diffusion. The diffusion in the Pd-alloy layer is modeled by taking the hydrogen chemical potential as the driving force of the diffusion in the metallic bulk. The interfacial phenomena (adsorption, desorption, transition from Pd-based surface to Pd-based bulk and vice-versa) were described by the same expressions used by Ward and Dao. The model separates the permeation steps and consequently their influence, quantifying the relative resistances offered by each of them. Comparison with some experimental literature data shows a good agreement. The developed tool is able to describe hydrogen transport through a supported Pd-based membrane, recognizing the rate determining steps (e.g., diffusion in the metallic bulk or in the porous support) involved in the permeation.
The concentration polarization coefficient was evaluated by an opportune coefficient[2] expressed as a function of the ratio of the flux calculated by means of this new validated complex model and the one obtained by the Sieverts' law utilizing the bulk driving force and hydrogen permeance. It was evaluated as a function of several operating conditions: up-stream hydrogen molar fraction ([0...1]), total pressure of upstream ([200,...,1000] kPa), total pressure of down-stream ([100,...,800] kPa), temperature ([300,...,500]°C), membrane thickness ([1,...,150] μm), permeance ([0.1,...,20] mmol m^{-2} s^{-1} $Pa^{-0.5}$) and upstream fluid-dynamic conditions (Reynolds' number).
The analysis shows that the polarization effect can be relevant not only when using very thin membranes (1 - 5 μm ca.), but also when thicker ones (100 μm ca.) are operated in specific conditions. The so-called "polarization maps", on which the influence of concentration polarization can be evaluated quantitatively in different conditions, provide concentration polarization coefficient in several operating conditions.

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Electrical resistivity and linear expansion of an hydrogenated Pd/Ag permeator tube

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Pd alloys pemeators are developed for separating ultra-pure hydrogen from gaseous mixture: other specific applications concerning the hydrogen isotopes purification and separation processes in the fusion reactors fuel cycle. Accordingly, the chemical and physical properties of hydrogenated Pd and Pd alloys have been widely investigated [1].
Our work has been aimed at measuring the electrical resistivity and the linear expansion of a Pd/Ag (with Ag 25 % wt.) permeator tube in both hydrogenated and non-hydrogenated conditions. The wall thickness of the investigated permeator tube was 200 μm while the total length was 128 mm. The electrical resistivity and the linear expansion of the permeator tube have been evaluated in a temperature and lumen pressure range of 50-400 °C and 100-400 kPa, respectively.
The results of the experimental tests are shown in figure 1 where the linear expansion due to the hydrogen uploading vs. the temperature is given for different lumen pressures. Hydrogen in Pd and Pd solid solutions expands the lattice not only because it is an interstitial solute, but also because its presence causes the filling of the Pd d-band [2]: Pd/Ag hydrogenated alloys show similar behaviour upon heating. The linear expansion of the Pd/Ag reduces both by increasing the temperature and by reducing the hydrogen pressure in the lumen side of the permeator tube.
The resistivity values of the hydrogenated Pd/Ag with temperature are shown in figure 2 for different lumen pressures: the highest resistivity value is reached when temperature approaches 300°C.

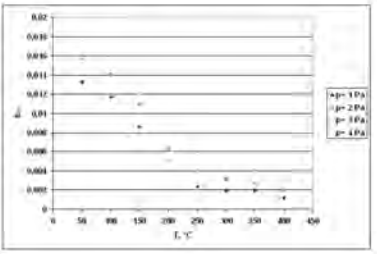

Figure 1. Temperature dependence of the linear expansion of the Pd/Ag hydrogenated for different lumen pressures of the permeator tube.

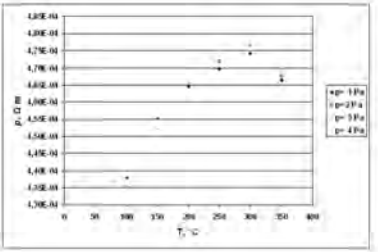

Figure 2. Temperature dependence of the electrical resistivity of the Pd/Ag hydrogenated for different lumen pressures of the permeator tube.

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Synthesis and characterization of $BaCe_{1-x}Y_xO_{3-\delta}$ protonic conductor

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In recent years, doped perovskite such as barium cerates ($BaCeO_3$), strontium cerates ($SrCeO_3$) and barium zirconates ($BaZrO_3$) have been studied as ceramic proton conductors for several technological applications: protonic membranes, hydrogen separation, catalytic support and solid oxides fuel cell components. Among those compounds, yttrium doped barium cerates have the best performances in terms of protonic conductivity at lowest temperature [1].

In this activity, variously doped BCY oxide powders were synthesized via a novel soft chemical route. The method is based on the formation of a metallorganic xero-gel at room temperature. The structural phase of powders and the dense pellets were analyzed using X-ray diffraction (XRD), while the morphology was investigated by field emission scanning electron microscopy (FE-SEM). The results of the XRD analysis (figure 1) show a pure perovskite phase both for the BCY powders and pellet, and the SEM microghaphs revel dense microstructure. Electrochemical impedance spectroscopy (EIS) measurement were performed on dense pellet under synthetic air flux at a temperature range between 200-750°C and frequency range between 10mHz-10MHz. EIS measurements were also performed at the same frequency range in wet hydrogen atmosphere. Figure 2 shows the Arrhenius plot of BCY_{20}, the activation energy is 0.40eV, in agreement with the values reported in literature [2].

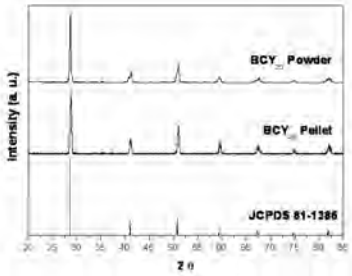

Figure 1. XRD patterns of BCY_{20} powder calcined at 900 °C for 6h, BCY_{20} pellet sintered at 1450 °C for 8h.

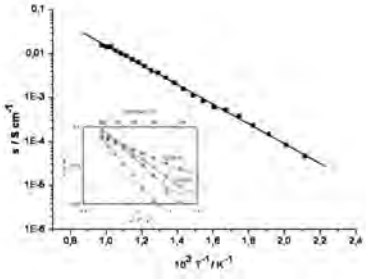

Figure 2. Arrhenius plot for BCY_{20}.

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HYDROGEN/DEUTERIUM ABSORPTION PROPERTY OF PD FINE PARTICLE SYSTEMS AND HEAT EVOLUTION ASSOCIATED WITH HYDROGEN/DEUTERIUM LOADING

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It has recently been recognized that nanoscale structures of Pd or nanosize Pd particles are essential to successfully observe low energy nuclear phenomena in condensed matter. Iwamura et al. used nanosize multilayers of CaO and Pd to induce element conversion [1]. Arata and Zhang reported that a loading of deuterium into nanoPd-ZrO_2 system generates heat due to D-D fusion reaction yielding He as ash [2]. Takahashi et al. has recently reported that they have succeeded in replicating Arata-Zhang's results [3]. For the nanoPd-ZrO_2 system, the number of the absorbed hydrogen per Pd atom is reported to be about 2.5, which is much larger than 1 [4]. It has been known that attaining D/Pd larger than 0.88 is favorable to observe excess heat in electrochemical loading of Pd with deuterium [5].

In this study, hydrogen/deuterium absorption properties were measured by using the Sieverts' method for Pd fine particles and Pd-γ Al_2O_3 dispersion systems in order to clarify the relation between H (or D)/Pd and the size of Pd particles. The Pd-γ Al_2O_3 samples were prepared by impregnating the γ Al_2O_3 support with an aqueous solution of $Pd(NO_3)_2$, followed by drying and heating in air. For these systems, the evolutions of heat associated with a loading of deuterium/hydrogen at ambient temperature up to 1MPa were measured using a flow calorimeter. It was found that a commercial Pd fine particle system with Pd-size of 10-20nm absorbed hydrogen up to H/Pd = 0.74 - 0.78 which almost agreed with the value reported for bulk Pd. On loading hydrogen, an evolution of heat was observed only at the initial stage of loading. A similar heat evolution behavior was also observed when deuterium was loaded. For Pd-γ Al_2O_3 systems, in which the size of Pd particles was 2-5nm, apparent values of H/Pd reaching 2.6 - 3.2 were observed for the as-synthesized state, depending on the Pd concentration. This value decreased greatly when the sample was degassed by evacuating at an elevated temperature after the first loading of hydrogen. Therefore, the oxidation of nano-size Pd particles affects the apparent H/Pd values. The variations of H(or D)/Pd values and heat evolution with cycles of loading and degassing will be presented mainly for Pd-γ Al_2O_3 system.

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Anomalous Heat Generation in Charging of Pd Powders with High Density Hydrogen Isotopes (I) Results of absorption experiments using Pd powders

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To confirm heat and ^{4}He generation by deuterium (D) absorption in nano-sized Pd powders reported by Arata and Zhang [1], and to investigate the underlying physics, we have installed a twin system of double structured vessels to perform flow calorimetry during D_2 or H_2 absorption by a variety of micronized Pd samples.

The first-stage experiments are described in detail in ref. [2]. The evolution of pressure and temperature after introduction of 1-MPa D_2/H_2 gas was divided into two phases. The first phase is zero-pressure interval, and in the second phase, pressure increases up to the stationary value. When D_2 gas was used with Pd-black, apparent excess heat production in the second phase was implied, although temperature oscillations and drift were too large to confirm the result.

Then in the second stage, the system was modified to improve the accuracy: The heat capacity of the reaction vessel was decreased, while increasing the mass of the test sample, to minimize the time constant of the calorimeter and maximize the sensitivity.

Nano-sized powders of mixed Pd and Zr oxides fabricated by Santoku Corporation, Kobe, Japan, have been used to reveal their interesting and exciting characteristics. In the 1st phase, D-gas charge gave 20~90 % excess heat compared to H-gas charge. In the 2nd phase, significant excess heat (about 2 kJ/g-Pd) for D-gas charge was observed, in contrast to near zero level output for H-gas charge. We will further examine the dependence of the anomalous excess heat on the experimental conditions such as the gas flow rate and the sample temperature. The anomalies and the possible mechanisms will be discussed in more detail in the succeeding presentation [3].

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Wave Nature of Deuterium Flux Permeating through the Palladium Thin Film with Nanometer Coating Layers --- (I) Experimental Observation

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Wave nature of deuterium flux permeating through the palladium thin film is revealed using nanometer coating layers. Three sets of experimental data[1,2,3] agree with wave in multiple-layer theory quantitatively or qualitatively. Other than granular particle diffusion model and surface catalyst model, the wave nature of deuterons inside the coating layers must be included in order to explain the experimental phenomena.

The anomalous deuterium flux permeating the thin wall of palladium tube showed a peak while the temperature of Pd tube was monotonically decreasing through 150°C to 120°C [1]. It was a hint that other than the diffusion there must be some different mechanism governing the deuterium flux permeating the thin Pd film, because diffusion coefficient was supposed to be a monotonic function of temperature. When deuterium molecule dissociated into 2 atoms, and entered the Pd surface as if a granular particle, it would be reflected by the single surface layer only. However, if its behavior was similar to that of a wave; then, it would feel more layers behind the surface layer. The reflecting wave from the surface would be determined not only by the surface layer, but also by the layers behind the surface. Then the reflection of wave should depend on the interference of several reflecting waves from several layers, and manifest itself a peak-wise behavior. This distinct feature might be tested by a deuterium flux permeating through a palladium thin film with multiple nanometer coating layers. Fig.1 shows the schematics of the apparatus, and the following plots show some results of observation. Under the same conditions, the Pd film with coating layers (Pd-TiC-Pd) has greater deuterium flux than Pd film without coating layers does unexpectedly.

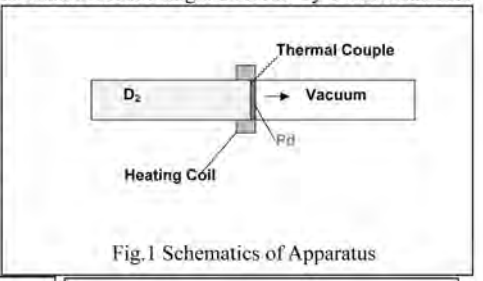
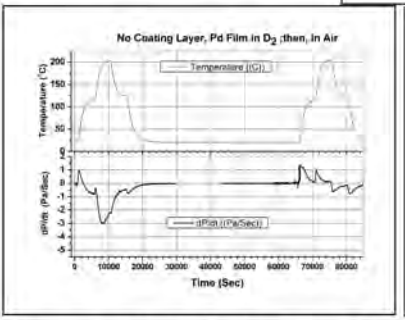
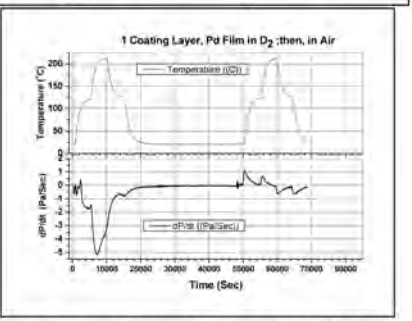


Fig.1 Schematics of Apparatus





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CALORIMETRY OF PULSE ELECTRO-MELTING OF PdD_X WIRES

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Several groups[1, 2] have reported anomalous effects in thin PdD_x materials stimulated by different forms of electro-diffusion. The ultimate extrapolation of this technology is the electrical heating of thin PdD_x wires resulting in destructive high-speed melting - "exploding wires". Exploding wire technology has been used for over 150 years to make fine metal particles[3].

Using the techniques of Celani *et al*[4-6] we are loading thin Pd wires electrochemically up to high loading and sealing their surface electrochemically. The wires are immersed in liquid nitrogen in a cryogenic nitrogen boil-off calorimeter. A short duration (~100ms) high current (~100A) electrical pulse is used to instantaneously melt the wire. The energy from the pulse and any excess energy produced from the extremely fast electro-migration inside the PdD_x will boil off a known amount of nitrogen. This nitrogen boil-off mass-flow calorimeter is used to compare the energy released from PdD_x wires to that released by pure Pd or Pt wires. This cryogenic exploding wire technique may yield very high power density anomalous energy releases.

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Confirmation of Heat Generation during Hydrogenation of Oil

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We have confirmed unusual reaction when heavy oil is heated in high pressure hydrogen gas with a metal catalyzer. Excess heat and weak radiation that assumed to be x-rays and gamma-rays were observed. After the test, almost of the sample and hydrogen gas remains in the same condition they were initially. There are reaction products such as other chemical compounds. However, the formation enthalpies for these compounds are estimated as endothermic. The heat generation sometimes reaches 0.1kW and has continued for several hours. There is a reasonably significant correspondence between the heat generation and the radiation emission. We have confirmed the same result with high reproducibility by controlling temperature and pressure. The anomalous energy generation cannot be the product of a conventional chemical reaction for the following reasons: At these temperatures, hydrogenation reactions are endothermic, not exothermic. The total heat release far exceeded any known chemical reaction with this mass of reactants. There is virtually no chemical fuel in the cell. There were few chemical reaction products. The components and chemical species in the cell including oil and hydrogen gas remained essentially as they were when experiment began, except that the platinum screen was coated with carbon. The emissions are thought that had been generated from some nuclear reaction. The reaction is reliably triggered by raising temperatures above the threshold temperature of ~530°C and the hydrogen pressures above 60 atm. It can be quenched by lowering the temperature inside the cell below ~500°C. When the necessary conditions are achieved, generation of heat is observed with high reproducibility. However, the amount of heat generated is not stable. Only a small amount of reactant is consumed during the experiment, presumably by conventional chemical reactions. We conclude the following: Anomalous heat generation was confirmed during heating of sample in high pressure H_2 gas. Sporadic emission was confirmed during high temperature experiment. A weak correlation was observed between heat and the emissions.

THEORETICAL MODEL OF THE PROBABILITY OF FUSION BETWEEN DEUTERONS WITHIN DEFORMED CRYSTALLINE LATTICES WITH MICRO-CRACKS AT ROOM TEMPERATURE

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In this paper, we wish to demonstrate that the deformation of the crystalline lattice, at room temperature, can influence the process of fusion of the deuterons introduced into the lattice by deuterium loading. In fact, calculating the probability of deuteron-plasmon fusion within a micro-crack, showed, together with the enhancement of the tunnelling effect, an increase of at least 1-3 orders of magnitude compared to the probability of fusion on the surface of the lattice. These phenomena open the way to the theoretical hypothesis that a kind of chain reaction, catalysed by the micro-cracks produced in the structure as a result of deuterium loading, can favour the process. The main features of tunneling traveling between two deuterons within a lattice is also studied in this paper. Considering the screening effect due lattice electrons we compare the d-d fusion rate evaluated from different authors assuming different screening efficiency and different d-d potentials. Then, we propose a effective potential which describe very well the attractive contribute due to plasmon exchange between two deuterons and by means of it we will compute the d-d fusion rates for different energy values. Finally the good agreement between theoretical and experimental results proves the reality of cold fusion phenomena and the reliability of our model.

THE FCC SUBSTRUCTURE OF THE NUCLEUS AND THE MAGNETIC INTERACTION AMONG NUCLEONS

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The strongest objection to "cold fusion" research since 1989 has been the assertion by nuclear theorists that low-energy nuclear reactions (LENR) "violate everything known about nuclear physics." We argue to the contrary that LENR are consistent with quantum mechanics (QM), and "violate" ***only*** various questionable assumptions of the 30+ established models of nuclear structure theory [1]. In fact, these "models" are known to be mutually-contradictory (a liquid nuclear interior in the liquid-drop model [LDM], a gaseous-phase in the shell model; local cluster formations in the alpha-particle model, no local interactions in the Fermi-gas model; a short-range nuclear force in the LDM, a long-range "effective" force in the shell model; etc.) and clearly indicate that nuclear theory itself is unfinished business [1].

We have previously shown that only one model of nuclear structure (the fcc lattice model) is consistent with both QM and the many empirical indications of an extremely high-density nuclear interior [2-4] (Fig. 1). Here, we demonstrate that the nuclear force that binds nucleons together into a superfluid lattice [4] ***cannot*** be a fictitious potential-well acting over 10-15 fm (as in the shell model), but, rather, must be a spin- and isospin-dependent, short-range force acting over distances of less than 2.0 fm, as known from nucleon-nucleon experiments. The only ***known*** force of sufficient strength to overcome the Coulomb repulsion between two protons is an in-phase magnetic force [5]. That is, at a center-to-center distance of 2.0 fm (which gives a nuclear core density of 0.17 nucleons/fm^3), the surface-to-surface distance of singlet-paired, same-isospin nucleons (each with a known RMS radius of 0.86 fm) is only 0.28 fm, corresponding to an attractive magnetic force of ~3 MeV. Triplet-paired nucleons of opposite-isospin show similar attraction. Provided that nucleons are arranged in an antiferro-magnetic fcc lattice with alternating isospin layers (Fig. 1), the nucleon build-up procedure is ***identical*** to that of the shell model. Moreover, using a realistic, short-range nuclear force, the lattice gives binding energies and nuclear radii similar to those of the LDM [2-4]. It is also noteworthy that this same fcc lattice of nucleons has been shown from QM calculations [6] to be the lowest-energy condensate of nuclear matter (Z=N), possibly present in neutron stars.

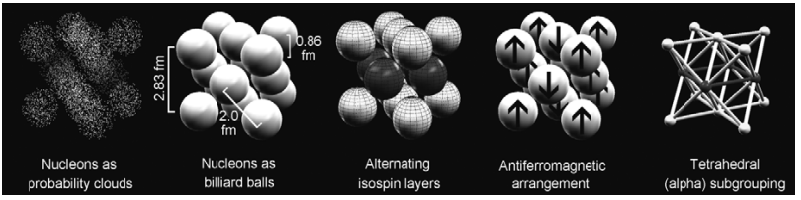

Fig. 1: The fcc unit structure with dimensions that give the known nuclear density.

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Why Electromagnetic-Dynamics Explains the Fleischmann-Pons Effect

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Many years-ago, Giuliano Preparata suggested the idea that "trapped photons" could be used to explain why cold fusion excess heat in the Fleischmann-Pons effect might take place. Because the language he used clashed with existing language, what he said was ignored. In fact, at a basic level, what he suggested was related to an important, key problem: Dealing with boundaries, in situations involving "photons." This problem is related at a fundamental level with a second problem that I suggested previously: That the real barrier for understanding how Cold Fusion reactions can take place, in the Fleischmann-Pons effect (FPE), is not overcoming the "Coulomb Barrier" but involves understanding quantum mechanics (QM). Specifically, the trapped photon picture that Preparata suggested illustrates a potentially important effect, which is involved with the fact QM does not require that the "picture" used in conventional fusion apply. A more logical "picture" includes electromagnetism in a time-dependent fashion (a point that Preparata also emphasized) and the idea that many particles can be involved. Then seemingly impossible aspects of the "conventional picture" become "not so impossible," but, in fact, "quite reasonable." A key source of confusion is that as opposed to a situation in which potentially reacting deuterons (d's) are required to have such high velocity that they can be treated as if changes in their electromagnetic interaction (EMI) are important only very near the location of the reaction, where the conventional tunneling picture applies (involving a static Coulomb potential), in a situation involving many charged particles, the effects of EMI can result in time-dependent changes that can become important far from the reaction. In fact, in what appears to be the most relevant, conventional fusion reaction (in which helium-4, in the form of alpha particles is released), evidence exists that the conventional "Coulomb Barrier" actually must be modified significantly in order to incorporate time-dependent features of the EMI that are necessary to impose the requirement that far from the reaction, the incident d's must have positive Bose Exchange symmetry and have net, vanishing spin. In this paper, I discuss a particular mechanism involving resonant electromagnetic dynamics. The associated picture is consistent with the conditions that are present in the experiments, the known laws of physics, and the underlying ideas suggested by Preparata. Predictions, based upon this alternative picture, imply that particular size crystals, involving Palladium (Pd) and particular, externally applied electromagnetic fields can be used to trigger excess heat in the FPE. I have provided a general picture, associated with resonant electrodynamics, that can be used to understand the associated physical effects. In the present paper, I give a more detailed, quantitative description that can be used to understand the associated dynamics.

Usefulness of Quasi-Particle Ion Band States in Modeling LENR Processes

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Considerable confusion occurred from a speculative conjecture that we suggested in 1989, concerning the potential role of conventional energy band theory in the "cold fusion" claims suggested by Fleischmann and Pons. Two important reasons for this are related to: 1. Misconceptions about what was taking place in the experiments, and 2. Limitations of conventional energy band theory. In particular, we proposed the idea that deuterium nuclei (deuterons) could occupy energy band states (ion band states)--analogous to the kinds of energy band states that electrons occupy in ordered solids--with the possibility of nuclear fusion. But conventional energy band theory has limitations, associated with the underlying quantum mechanics. In particular, band theory involves single-particle quasi-particle wave functions. As a consequence, the effects of collisions have conventionally been treated in a semi-classical fashion, approximately. It was not obvious, initially, how to demonstrate that deuterons that occupy ion band states could ever have sufficient overlap at nuclear-scale dimension to initiate fusion reactions. To illustrate that sufficient overlap can take place, we constructed a model, in which both the wave functions that describe the deuteron-deuteron separation and center-of-mass variables possess Bloch symmetry, in analogy with how same-charged particles--electrons in atomic helium, that Hylleraas identified--can overlap at a point. We also suggested that by introducing "cusps" in the separation variable, deuterons could also have appreciable overlap "at a point", which suggested that at nuclear-scale dimension appreciable overlap might take place. This argument, although provocative, failed to inspire wide-spread acceptance. An important reason for this is that the argument involves a number of approximations, and does not include the time-dependent features that are commonly viewed as being important. Also, the argument is based on formalism (involving variational principles, time independent quantum mechanics, and a generalization of conventional band theory) that is both new and foreign to people who have been involved with Cold Fusion research, and in other areas of modern physics. In spite of this, there are ideas associated with Bloch symmetry and the possibility that deuteron quasi-particles can obey this symmetry, which might provide a framework for postulating models that might be relevant in LENR areas beyond the initial context (associated with stoichiometric PdD), where the initial model was applied. For example, Bloch symmetry (as envisioned initially in 3-dimensions), can also occur in 2-dimensions. Features of the associated coherent effects might also apply at the kinds of interfaces that occur in the CaO/Pd systems that have been used by Iwamura et al. One of us (TC) has also suggested that these kinds of quasi-particle arguments might also apply in Oriani's observations involving alpha-particle showers that occur far from heat-producing cathodes.

EVALUATION OF D/D REACTION RATES IN METALLIC LATTICES AS A FUNCTION OF DEUTERON ENERGY

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Recently, experimental observations were made, showing an enhancement of d/d reaction rates, for energies of the deuteron between 3000 and 10000 eV on the one hand [1] and at very low energy of the deuteron on the other hand [2]. For both experiments, this enhancement was ascribed to the screening effect of the electrons of the metallic lattice where the reactions take place.

In [3], the contribution to the d/d reaction rate enhancement, of an attractive Yukawa type of potential, acting between nucleons, was evaluated. The combined effect of this potential and of the screening of the lattice electrons was shown not to be sufficient to explain the whole enhancement observed for both experiments [1] and [2]. A coupling between the deuterons in the target with the incident deuteron beam was thus invoked [3] to explain the enhancement observed, by fusion reactions taking place between the deuterons already trapped in the target.

Using the model developed in [3], the energy production resulting from the interaction of a 1 W beam of deuterons with a metallic target loaded with deuterium (1 mmole d), was evaluated as a function of the incident deuteron energy. 3 zones of interest were identified: a zone corresponding to hot fusion (deuteron energy round 100 000 eV), a zone corresponding to Cold Fusion (SPAWAR experiments - deuteron energy round 10 eV) and a potentially interesting intermediate zone (deuteron energy between 500 and 1000 eV) were sizeable and industrially significant amounts of energy production can be expected. It is proposed to call this last zone CMAF zone (Condensed Matter Assisted Fusion).

This approach will be detailed and practical ways to generate deuterons in the CMAF energy window will be presented.

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HEAVY ELECTRONS IN NANO-STRUCTURE CLUSTERS IN THE SOLID SURFACES AND THEIR INTERACTIONS WITH POSITIVE NUCLEI SUCH AS PROTONS AND DEUTERONS

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The existence of heavy electrons is found theoretically in nano-structure clusters that are in the solid surfaces. Basis of the investigation is the electron band structures of nano-structure clusters in these surfaces. The existence of electron energy pockets is found for the electrons in the conduction bands of these clusters that can be considered to be nano-confining potential valleys of dimensions in the range of the primitive cell. The electron wave function of the confined electron is determined. Further simultaneous interaction of the confined electron with both external electro-dynamic field and positive nuclei is investigated on the basis of Schroedinger equation having Hamiltonian of three parts. The first part describes electron behavior when there are not external energy influences over the electron located in pocket. The second part is connected with interaction of confined electron with external electro-dynamic field having certain amplitude and certain frequency. This part is created on the theory of the displaced harmonic oscillator. The third part of the Hamiltonian describes interaction of confined electron with positive nuclei. The Schroedinger equation is solved and the following conclusions are found based on the solution:

- the electron effective mass regarding interactions with the positive nuclei changes and the following previously determined formula remains effective in case of electrons confined in nano-clusters in solid surface (m^* is zone effective mass, E is electron energy, U_0 is potential barrier, ξ_μ is the electrical field strength of electron-positive nuclei interaction, and q is electron charge), and these electrons are determined to be heavy because normally $m_{eff} >> m_0$:

$$m_{eff} = m^* m_0 \exp\{(2/\hbar)\sqrt{2m^* m_0}\int_0^a [U_0 - q\xi_\mu x - E]^{1/2}\,dx\}$$

- the electron-positive nuclei interaction remains weak for any distance and the term $q\xi_\mu x$ remains negligible.

- the critical electron effective mass is determined as value for which the distance between the electron and the deuteron (proton) becomes 1.5fm, and the corresponding parameters of the electro-dynamic field such as magnitude and frequency are found. It is found that a stable electron-deuteron (proton) domain appears.

Interactions of the electron-deuteron (proton) domain with other positive nuclei are investigated in particular with other deuteron (proton) and with metal nuclei. It is found that the first interaction gives stable deuteron (proton)-deuteron (proton) pair with inter-nuclei distance less than 1.5fm. Also it is fond that the second interaction gives transmutation reaction. In particular it is found theoretically and it is observed experimentally by the author the following transmutation reaction: Al(P:13, N:14) + p --> Si(P:14, N:14).

Role of Cluster Formation in the LENR Process

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Sufficient experimental observation has now accumulated to show that the mechanism producing LENR effects must have at least the following characteristics:

1. The process involves clusters of D or H.
2. The clusters form spontaneously under special conditions by release of energy.
3. As expected, cluster formation is very sensitive to the deuterium concentration in the environment.

These three partial requirements limit the nature of any proposed mechanism used to explain LENR and suggest conditions that might accelerate the process. Evidence supporting this assertion will be presented along with speculations about how these clusters might form.

TUNNELING BENEATH THE ^{4}He* FRAGMENTATION ENERGY

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At ICCF-14, we presented the means whereby the repulsive Coulomb barrier between hydrogen (deuterium) nuclei is reduced in length, perhaps by orders of magnitude. This mechanism, involving optical phonons and electric fields (internally or externally generated) in a lattice that induce the formation of H^-H^+ (D^-D^+) pairs, increases the tunneling probability by more than 100 orders of magnitude. It has additional major consequences.

The lattice constraints and collision processes force the ions into a temporary, but cyclic, 1-D configuration that greatly deepens the electron ground-state potential well. The tightly-bound and energetic electron pair (a local-charged Boson - the lochon) becomes more than strong screening, it becomes a binding force between the nuclei. Thus, the Coulomb-barrier height is reduced as well as its length. With this greatly enhanced barrier-penetration probability, the energy level of nuclei with reasonable tunneling probability drops from the multi-100 keV range down into the eV range.

The ^{2}He (diproton) and first excited state of helium-4, ^{4}He* (unable to decay via gamma radiation) are above the fragmentation energy (i.e., they are more likely to fragment than to exist for long or to decay to the ground state). Normal tunneling is into these resonant states (excited or fragmentation levels). With the ability of low-energy nuclei to tunnel from an appropriate lattice, the possibility of lower-energy excited compound nuclei becomes real. If, with the lochon, the helium-2, or excited helium-4 nucleus, does not have sufficient energy to fragment, and gamma decay is highly forbidden, how does it shed the excess energy? It is proposed that this condition is the basis for the experimental observations of CMNS.

Depending on the actual energy of the excited (compound) nuclei, the decay process could include fragmentation, or not. This accounts for the observations in CMNS of excess heat, in both p-p and d-d reactions, and the observations (or absence) of tritium, ^{3}He, neutrons, and ^{4}He in the d-d reaction. This variation (unpredictability) of results, heretofore the stumbling block to acceptability of CMNS, is now perhaps the greatest validation of its existence. Furthermore, the proposed mechanism accounts for observed "transmutation," something that we didn't accept for a long time.

The key to the mechanism is the lochons, which during the collision process attain significant energy from the nuclear Coulomb potential (many keV; but, being tightly bound in ground states, they do not radiate). During the fusion process, they would divide and can perhaps attain energies in the MeV range from coupling with the nucleons accelerating in the nuclear potential (and these electrons would radiate - bremsstrahlung). This collision/radiation process lasts until: 1) the neutral entity (^{2}He* or ^{4}He*) drifts into a neighboring nucleus in a transmutation process; 2) one (or more) of the nuclear electrons combines with a proton ($p + e \Rightarrow n + \nu$); or, 3) diproton fragmentation or the ^{4}He ground state is reached. Thus, all major observed CMNS processes are explained. (Levels and observability of the Bremsstrahlung and neutrinos must still be determined.)

Oscillatory and Directional Emission Properties of Transition Metal Catalysts – Systems with Statistical Reliability

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23 June 2009 submitted to ICCF-15

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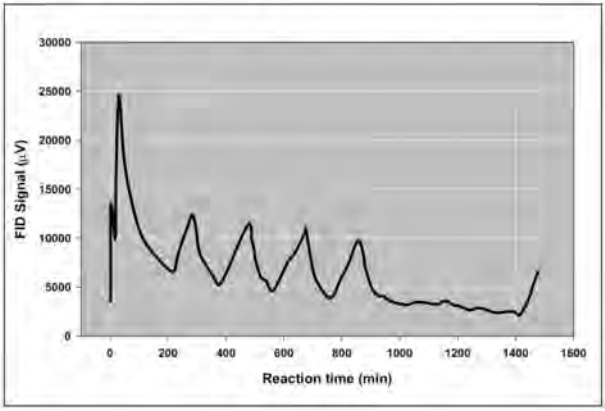
The properties of hydrogen in metals are extensively studied because of the great variety of effects observed. Amongst the most unusual and controversial proposals is that the electromagnetic forces in metals can have a significant effect on the strong force states of nuclei that compose or are embedded within these metals. The Fleischmann-Pons Effect, apparently non-chemical heat production in a Pd metal highly loaded with deuterium, is an out standing case – "anomalous" is the polite term used to characterize this effect.

This paper will bring to the attention of researchers in CMNS some observed properties of transition metal catalysts that may bare on one of the more perplexing properties of the FPE and CMNS experiments, namely, the difficulty in gaining adequate control of these physical systems. Figure 1 is taken from Mango & Jarvic, http://www.geochemicaltransactions.com/content/10/1/3.



The fluctuating evolution of the hydrocarbons in this experiment occurs in a system of constant temperature heated material and constant flow carrier gas over the rock that is being heated. Why does it oscillate? It is attributed to deterministic chaotic processes that arise in parts of the system's phase space, generally far from equilibrium. Other unusual properties, such as experiments on single crystal Ni(111) show sharply directional emission of desorbed hydrogen as reported by Chorkendorff, Russel & Yates, Surface Science 182 (1987) 375-389. These properties of transition metal catalysts suggest that useful control of the FPE may lie in the methods of chemical engineers and their use of functional or process models,.

QUANTUM MECHANICAL STUDY OF THE FLEISCHMANN-PONS EFFECT

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The Fleischmann-Pons Effect [1] (FPE) was swiftly rejected when published in 1989, yet a significant number of researchers have since reported energy gains in similar experiments; for a review see ref. [2]. These gains have been associated with "cold fusion" or Low Energy Nuclear Reactions (LENR) where energy is released from a deuterium-deuterium (d-d) fusion. Clearly, this raises fundamental questions because the probability of a d-d fusion, under the conditions of the FPE cell, is extremely small. As stated in ref. [1], "it is necessary to reconsider the quantum mechanics of electrons and deuterons in such host lattices."

The goal of this paper is to predict possible changes in the probability of d-d fusion, caused by perturbations to the energy barriers or positive interference caused by the effects of adjacent atoms in a lattice. We report preliminary work on formulating quantum-mechanical models of the behavior of deuterium atoms trapped in a lattice.

In the first model we examine possible non-linear oscillation effects. A time *dependent* solution of the Schrödinger equation is presented for an oscillator problem in which (pseudo) 3-dimensional d-d particles are constrained to interact along a 1-dimensional axis. Non-linear excursions from stationary electronic configurations are investigated with the intent to understand possible enhancement of quantum barrier effects and enhanced probability of electron capture by protons.

In the second model the effect of adjacent lattice atoms on fusion is examined with a 1-½ dimensional model. First a quantum barrier model is formulated using the transfer matrix approach. Then additional barriers are introduced in the form of adjacent lattice atoms. Initial results show possible resonance structure for the transmission of incoming deuterons through deuterium atom nuclei, which implies an increase in fusion probabilities at particular deuteron energies.

It is noted that the energy gains observed in FPE experiments often occur in highly dislocated metal lattices. The possible role of these dislocations in facilitating the d-d fusion process is examined. {LA-UR 09-03526.}

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PLASMON BASED MECANISM OF NUCLEAR REACTION IN METAL DEUTERIDES

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Irradiation of Pd – D_x and Pd/PdO:D_x systems by electron beam with energies of 10 -50 keV at a room temperature causes an intensive release of deuterium atoms [1], and yield of 3 MeV protons and 1 MeV tritons -products of d(d,p)t reaction [2]. It is known that at irradiation of metals the accelerated electrons are lose its energy on excitation of electronic subsystem. However, a lifetime of the electronic excitations in metals is rather short ~10^{-15} s and it is not clear how energy from electron subsystem transfer to deuterium. To understand of a mechanism of this transfer it is necessary to study electronic and atomic structure of the Pd – D_x system. We believe that the plasmon mechanism, associated with collective excitations of the electron subsystem of the metal, is able to explain the observed processes. We performed the *ab initio* calculations of the electronic structure for both pure Pd and the Pd-H solution and investigated the effect of deuterium on the electron properties of palladium. The calculation was done by the full-potential linear method of augmented plane waves in the framework of the local approximation to the density-functional theory. Presence of deuterium atoms in the Pd lattice leads to the appearance of the bonding states below the bottom of the Pd valence band, and antibonding states above Fermi-level higher, than 4.5 eV [3]. An analysis of a spatial distribution of these states testifies that both of them have a local character. Population of the antibonding states in irradiation process leads to weakening of the metal -deuterium bonds and to a simplification of deuterium atoms migration on a crystal.

We also have calculated a spectrum of the collective electronic excitations for Pd and PdH. The calculation of loss function Im[$(\varepsilon_{00}^{-1}(q, \omega)$] and dielectric matrices $\varepsilon_{00}(q, \omega)$ was performed in the chaotic-phase approximation by the self-consistent method of the norm-conserving pseudopotential [3]. These a*b initio* calculations showed that dissolving deuterium in palladium considerably reduces dominating plasma frequency of the metal from ~7.2 eV in pure Pd down to ~4.1 eV in PdD. It means that the basic part of the ionizing-radiation energy are absorbed in PdD due to the plasmon excitation which localized in a neighborhood of deuterium atoms. As our preliminary calculations showed the plasmon oscillations of electron density produce strong (E ~ 10^{10} V/m) local (L ~ 10^{-10} m) electric fields in the neighborhood of deuterium atoms. Deuterium atoms in this field are capable to be accelerated to energy sufficient for nuclear DD-reaction.

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ACCELERATED LOW ENERGY NUCLEAR SYNTHESIS ON THE BASIS OF CORRELATED STATES OF INTERACTING PARTICLES

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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. 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 (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. The presence of a partial correlation of different eigenstates forming the correlated superpositional state causes the partial mutual quenching of all eigenwaves reflected from the walls of the potential well, i.e., causes the destructive interference, which leads to the increasing of the coordinate variance σ_q and partial clarification of the barrier. At full correlation of all eigenstates the full damping of reflected waves occurs, which gives the complete transparency of the barrier at any low energy. Another interpretation is the following: formation of correlated state leads to the cophasing and the coherent summation of momentum fluctuations of the various eigenstates. It leads to increasing of both momentum variance σ_p 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 correlated states. Here $r_{AB} = \sigma_{AB}/\sqrt{\sigma_A + \sigma_B}$ is the coefficient of correlation, which determines the cross correlation of A and B, $\sigma_{AB} = \langle \hat{A}\hat{B} + \hat{B}\hat{A}\rangle/2 - \langle A\rangle\langle B\rangle$ is the cross variance of A and B [2], $|r_{AB}| \leq 1$.
We have determined the form of optimal dependence of the correlation coefficient $r_{AB}(t)$ on time, at which the formation of a maximally correlated states of particles and the attainment of the maximal variances σ_q , σ_p are possible. The optimal mechanism of asymptotic formation of completely correlated states of a particle with the great increase of σ_q under the potential barrier and similar giant increase of nuclear reactions probability is determined.
It was shown for the first time that in real nuclear-physical systems very sharp grows (up to 10^{30}-10^{50} and more times!) of Coulomb barrier transparency at very low energy with the increase of correlation coefficient 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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Clusters with Picometer Distance of Deuterons and LENR

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The probability of pm-Ms reactions for low energy nuclear reactions LENR and the semi-empirical derivation of 2 pm deuteron screening on palladium with a reduction factor 14 in Coulomb repulsion compared with a usual plasma factor 5 [1] was confirmed later by direct experiments [2]. Generation of 2pm distance clusters of about 150 deuterons based on this screening and possibly by a Casimir force [3] permitted understanding of compound reactions as measured with the 155 nucleon minimum measured at LENR. These kinds of deuteron clusters were directly measured by SQUID [4]. Based on screening and comparable values of a Wigner-Seitz radius for very dense deuteron clusters of stable Rydberg matter in defects of iron oxide [5] with measured 2.3 pm nuclear distance is another access which may lead to an understanding of the LENR processes [6].
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EXOTIC NUCLEAR PHYSICS: FROM COLD FUSION TO ANTIKAONIC NUCLEAR CLUSTERS

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One of the more controversial recent issues in Hadronic and Nuclear Physics is the possible existence of the so-called AntiKaonic Nuclear Clusters (AKNC). They are strange (S=-1, -2) nuclear systems composed by nucleons strongly bound to one or two AntiKaons: This topic is connected with the possible existence of exotic nucleon bound states like pp or ppp, with the possibility that a high-density nuclear medium will be created around the AntiKaon, that could l seed for the understanding of the dense nuclear matter in the neutron stars.
In 2002 Akaishi and Yamazaki (1) predicted the appearance of discrete, narrow bound states of Kbar in few-body nuclear systems. The search for such systems started quite soon with non-dedicated experiments at Laboratories of KEK (Japan), Frascati (Italy) , CERN (Switzerland). Saclay (France)
The results are somehow contradictory concerning the statistical significance of the reported pea interpreted as the signature of the existence of AKNC, not exceeding 5 sigmas, as well as the va of the Binding Energies and Widths (2). Also from the theoretical point of view several authors argue strongly against the possible existence of such systems.
A few dedicated experiments were approved with the aim of ascertaining the existence of AKN and will give the first results by next year.
The situation is somehow reminiscent of the first beginning of Cold Fusion (conflicting experimental results, conflicting theoretical approaches). Similarities and differences will be discussed in the talk, in particular concerning the acceptance by the physicist' s community..

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CAN WATER BE THE ORIGIN OF EXCESS ENERGY?

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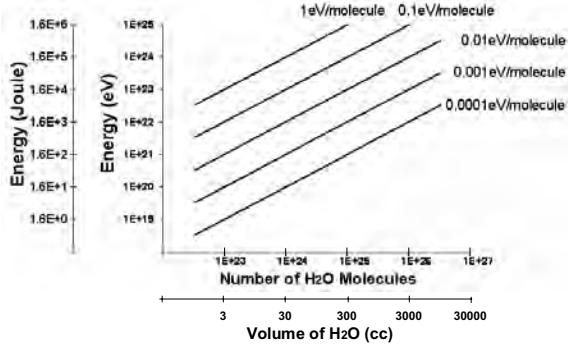
There are four sources of hydrogen isotopes for loading solids in Lattice Enabled Nuclear Reaction (LENR) experiments: (1) liquid electrolytes, (2) gases, (3) plasmas and (4) beams. Four types of measurements are made to determine the outcome of such experiments: (1) excess power and heat, (2) nuclear reaction products, (3) energetic radiations and (4) very low energy phenomena. This paper deals with electrochemical input and heat output.

Critics of LENR research have identified several potential sources of error. Recently, accusations of mistakes in measuring input powers and energies were made again. They were refuted on the basis of measurements. Earlier, the question of whether or not defect energies in a metallic cathode could account for excess energy were addressed and laid to rest [1].

In this work, we examine the possibility that very small energy changes due to variations in the configurations of many water molecules in the electrolyte could be a false source of excess energy. This is a third scale of energies per event, after nuclear reactions (MeV) and chemical reactions (eV), on a par with molecular vibration energies (meV). Atomic level energies due to chemical reactions of metals (in the cathodes) have been shown to be insufficient to explain excess energy. We have now examined energies on the molecular level to determine if they have any possibility of explaining observed excess energies. The conditions and results of some LENR experiments, and the data in this figure, rule out the possibility that small energies from many water molecules can explain excess heat.



Relationship between volume (and number of molecules) of water, and the excess energy in eV (and Joules), with the energy per molecule relating the volume and excess energy.

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THE ROLE OF CATHODE'S SURFACE PROPERTIES IN THE ELECTROCHEMICAL DEUTERIUM LOADING OF Pd FOILS

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Recent experimental evidences clearly indicate that the reproducibility of excess heat production is correlated with the cathode surface properties [1]. To support the results, a theoretical frame has been also developed, that suggests that a relevant role in the excess heat production is played by the electrodynamics processes at the cathode interface [2]. In particular, one of the mechanisms involved is the enhancement and spatial localization of the electro-magnetic field at the metal/electrolyte interface, promoted by proper surface roughness and morphology.
A further point to be considered is the dynamic character of the metal/electrolyte interface during electrochemical D loading, that derives from the coupling between the different interface characteristics. Surface reconstruction of the metallic cathode is expected to happen, due to corrosion-deposition mechanisms, D/H transport, stress relaxation and defect production, and so on. All these mechanisms both affect and are affected by the surface properties, such as the morphology of the metal/electrolyte interface, the metallurgical and crystallo-graphical structure of the cathode and the presence of contaminants.

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CHARGED PARTICLE EMISSIONS AND SURFACE MORPHOLOGY OF THE Pd/PdO:D_x AND THE TiD_x TARGETS UNDER AN ELECTRON BEAM EXCITATION

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Recent *ab-initio* theoretical study [1] of interaction between electromagnetic radiation and metal deuterides indicate a new mechanism for deuteron acceleration, which along with possible large electron screening in the metal targets [2] could potentially strongly enhance the yield of DD-reaction in metal deuterides at room temperature. In this research we continue our study with regards to the role of electromagnetic excitation of hydrogen subsystem in metal deuterides to enhance the yield of low energy nuclear reactions (LENR). To this aim we have carried out 5 series of experiments on charged particle detection using plastic track detectors CR-39, under in-vacuum electronbeam stimulation of various metal deuterides during spontaneous deuterium desorption (if any) from the deuterated samples. In order to identify the type and energy of emitted particles the detectors were covered by metal (Al and Cu) films of various thickness. Moreover, the sequential etching technique, involving CR-39 etching in the range of 7-28 hr (removed CR-39 depth in the range of 9-37 μm) has also been applied. The obtained track diameters were compared with that obtained in calibration experiments, using CR-39 bombardment with charged particles (protons and a) of certain energy. We showed that electron beam stimulation of the D-desorption from Pd/PdO:D_x and TiD_x targets is caused by statistically significant emissions of DD-reaction product (3 MeV protons and 1 MeV tritons), as well as high energy alpha particles. Simultaneously, the blank experiments that included Pd/PdO:H_x charged particle measurements under e-beam excitation as well as the Pd/PdO:D_x and TiDx runs in the spontaneous D-desorption mode in vacuum (without e-beam bombardment) showed zero charged particle emission yield. Extrapolation of both DD-reaction cross section and the enhancement factor to very low deuteron energy (E_d ~ 3.0 eV) with a reasonable screening potential U_e = 750 eV, allowed to describe satisfactorily the detected DD-reaction yield in Pd/PdO:Dx target under e-beam excitation. This result strongly supports the theoretical prediction [1] with regards to electron excitation of the D-subsystem in the Pd/PdO deuteride. The surface morphology of the Pd/PdO:D_x samples loaded with deuterium electrochemically, prior to and after the electron beam bombardment has also been studied using SEM, AFM and STM techniques. It was found that electron beam interaction with the surface of the Pd/PdO:D_x produce specific channels of 100-500 nm in diameter as well as deep craters with the diameter of several microns, while the surface which has not been subjected to the e-beam bombardment shows smooth PdO structure. The origin of these surface defects and their role in deuteron acceleration (channeling) will be discussed.

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INTERACTION OF THE ELECTROMAGNETIC RADIATION WITH THE SURFACE OF PALLADIUM HYDRIDE CATHODES

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The change of the electronic density of metallic Pd due to the hydride formation and to the build-up of the double layer, rising at the metal-dielectric interface when an electric field is applied, is involved in the variation of the metal dielectric function. A model including also metal surface roughness has been developed to take into account such modifications.

INTEGRATED APPROACH FOR HIGH RESOLUTION SURFACE CHARACTERISATION: COUPLING FOCUSED ION BEAM WITH MICRO AND NANO MECHANICAL TESTS

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At present, mechanical characterisation of engineered surfaces is gaining more and more interest for the growing industrial application of surface modification and coating techniques, which are usually applied to improve either surface mechanical or functional performances (i.e hardness, load bearing capacity, wear resistance, surface free energy and chemical reactivity, electrical resistivity, thermal conductivity,…).
Furthermore, it has to be considered that the development of nanostructured materials and the growing use and application of nano-systems and nano-structures make the use of advanced procedures for nano-scale mechanical characterisation strictly necessary; in other cases, mechanical behaviour can be strongly influenced by microstructural and size effects (grain size, defects, interfaces, porosity,…), so multi-scale characterisation procedures are strongly needed for a determination of the correct correlation function among process parameters, surface properties and in-service performances.
It is therefore clear that a comprehensive, statistically reliable, economically sustainable procedure for the characterisation of engineered surfaces has not yet been developed in literature, especially when a strong microstructure and size dependent behaviour is observed.
In the present work, a new developed characterisation procedure for the mechanical characterisation of enginireed surfaces is presented, based on the combined use of high resolution microscopy (FIB-SEM, TEM, AFM) and surface mechanical characterisation techniques (nanoindentation, scratch testing).
In particular, two case studies are reported:

- Analysis of residual stresses of engineered surfaces by coupling focused ion beam controlled material removal and nanoindentation testing
- Nano-mechanical characterisation of sputtered niobium thin films for application in accelerating cavities;

All reported results arise from the application of integrated methodologies, which start from indentation or scratch experiments and finally come to the evaluation of mechanical properties of investigated materials, by the support of modelling (both analytical and numerical) and high resolution morphological and microstructural characterisation activities, such as Scanning and transmission electron microscopy (SEM, TEM), Focused Ion Beam microscopy (FIB) and Atomic Force Microscopy (AFM) techniques.
It is shown that only by the combination and synergic use of surface mechanical testing and SEM-TEM-FIB- AFM microscopy a reliable correlation between surface properties and in service performances can be obtained.

Light Scattering from a Rough Palladium Surface: Theory and Experiment

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There is still a great interest in the determination of microtopographic properties of rough metallic surfaces from light scattering measurements. Although the use of the real space imaging techniques such as atomic-force microscopy (AFM), and scanning-tunneling microscopy (STM), allow to probe directly the surface morphology, indirect methods based on the light scattering from the sample surface still keep relevant advantages such as the contactless methodology, large sampling size, the capability to detect nanotopographic surface features, heterogeneous nanostructures, nano-objects, surface plasmons etc.

In this article we present a new compact laser device that has been designed and realised for nondestructive optical and morphological characterization of some rough palladium samples subjected to an electrolytic process (i.e. cold fusion) [1]. Such a characterization was a crucial and challenging task of a joint collaboration among Dipartimento di Energetica Sapienza Università di Roma, ENEA Frascati, and Energetics LLc, to explore possible correlations between the surface optical properties and the measured excess of heat.

The laser device measures the in plane scattered intensity in the whole range of scattering angle [-89°, +89°] (0° is for normal incidence) coming out from rough palladium samples. The scattered light detected by the Si-photodiode is finally analysed by a dedicated software which allows to invert the experimental data, reconstruct the statistical properties of the surface, and eventually detect the presence of surface patterning and surface plasmons.

The invesigated samples originally come from a 1 mm thick palladium slab subjected to several surface treatments which enhanced the surface roughness. The slab has been first rolled and reduced to a 50μm thin foil. Immediately after rolling the Pd foil has been annealed under vacuum conditions for 1 h at about 900 °C. The high surface roughness has been obtained by means of a chemical etching of the sample, which has been treated with a solution of Nitric and Cloridic Acid with a 1:3 volume ratio (aqua regia) for about 120 s. The morphology of the samples has been first investigated by atomic force microscopy (AFM) which allows to estimate the sqr roughness and the geometrical autocorrelation function.

The samples are finally investigated by the new laser device. The light scattering data are processed by iterative algorithms which allows to de-convolve the data and solve a nontrivial nonlinear inverse problem, finally giving the optical autocorrelation function to be compared with the geometrical autocorrelation function given by AFM. The different results among techniques are deeply discussed, and their complementarity is also demonstrated.

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MULTIFUNCTIONAL ION BEAM INSTALLATION "HELIS" AS A NEW INSTRUMENT FOR ADVANCED LENR RESEARCH

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The ion beam installation HELIS (P.N. Lebedev Physics Institute, Moscow, Russia) represents an ion accelerator of light elements with atomic number in the range Z=1-54 with ion energies ranging from 0.5 to 50 keV operating at deuteron current densities up to 2 A/cm^2 and intended to perform a wide spectrum of physical experiments related to LENR:

- study of collisions of light nuclei with solid target at very low energies,
- study of DD-reaction enhancement down to E_d = 1 keV and multi-body (3D) reactions in metal targets
- study of elementary and collective processes in ion-beam plasma, formed at interaction of intensive ion beam with gas and/or solid targets;
- preparation of thin-film coatings of various materials (including oxide films) by ion beam sputtering method.
- possibility of direct calorimetric measurements of excess heat *in-situ* during ion bombardment of metal targets.
- He-4 measurements during D-bombardment with quadrupole mass-spectrometer;
- direct X-ray measurements during metal target ion bombardment;
- four probe resistivity measurements of D-loading in Pd targets

The performance of the ion beam of the duoplasmatron:
Total hydrogen beam current (at 50 keV) $\leq$50 mA
Energy range 1 -:- 50 keV
Energy spread 10 -:-100 eV
Reduced emittance $2\cdot10^{-5}$ -:- $5\cdot10^{-5}$ cm·rad
Except the basic ion source (duoplasmatron) with ion current up to 50 mA HELIS facility is equipped by two more additional sources of ions: (i) high-frequency source with a current up to 1 mA and energy of ions $\leq$30 keV (Emittance at 30 keV ~$1.5\cdot10^{-3}$ cm·rad) (ii) high-frequency source with a current up to 8 mA and energy of ions 0,25-:-0,5 keV.

The HELIS facility can be used for study of dd- and dT-reactions yields from various targets at low energy of deuterons and can be equipped by various nuclear detectors, including dE/E Surface Silicon Barrier detector pair, CR-39 plastic track, neutron and X-ray detectors.
In general, the HELIS facility with additional installations mentioned above, will allow us to carry out full LENR experiment upon a deuterium implantation into metal targets, involving simultaneous measurements of excess heat, D-loading and He-4 emission, along with accompanying nuclear radiations.

CHARACTERIZATION OF MATERIALS BY MEANS OF LASER-BASED TECHNIQUES

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Laser-based techniques are more and more used in the field of materials processing and analysis.

In particular, laser spectroscopic techniques as the Laser Induced Breakdown Spectroscopy (LIBS) and Laser Induced Fluorescence (LIF) have been applied to investigate the chemical-physical properties and the morphological structure of several kinds of materials. Some results in different fields of application are reported.

Poster Papers

EXPERIMENTAL IMPLEMENTATION AND CHARACTERIZATION OF AN ELECTROLYTIC CONFINED PLASMA

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The thermodynamic behaviour of a glow discharge plasma cell - constituted by a tungsten rod cathode and a steel grid anode in alkaline solution - is analyzed in this paper.

Analogous experimental studies, performed first by Mizuno et al. [1-5] some years ago, followed by other authors [6-10], showed that a confined plasma on cathodic region (composed by electrons, potassium and hydrogen ions present in electrolytic solutions) seems to generate an output thermal energy that is anomalously higher than the input electrical energy supplying the system.

In our new experimental arrangement, developed implementing a previous set-up extensively described in [11], we obtained an input/output energy ratio in the range 1.7 ÷ 2.0. This interesting anomalous behaviour occurs in particular experimental conditions in what concern the chemical composition of the electrolytic solution, electrical supply, electrodes and cell geometry, etc.
Experimental set up is composed by an electrolytic cell in which are introduced a power-meter system to measure input electrical energy, having a 20 kHz sampling rate, and a dynamic flux calorimeter to measure output thermal energy from the cell system, respectively.
Each experimental measurement on the plasma system was followed by an additional test performed using a heater resistor, of equivalent volumetric characteristics as the glow discharge, and supplied by the same electrical energy, in order to perform a comparison between the glow discharge system and a standard joule heater in the same experimental conditions. Some considerations about the inductive behavior of this kind of plasma, and the supposed theoretical necessity of a higher sampling rate acquisition (from 20 kHz to more than 1 MHz) for a genuine analysis of the plasma electric parameters, are made. The possible convergence of the plasma parameters gives an interesting possibility to give an upper limit to the sampling rate without physically relevant measurement errors. A possible explanation for the measured higher output thermal energy with respect to the input energy is proposed through a parallel between this phenomenon and piezonuclear reactions experimental evidence, in which neutrons production is involved [12]. The obtained experimental results are reproducible, therefore we can state that the new developed experimental system is highly reliable.

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ABNORMAL EXCESS HEAT MEASURED DURING MIZUNO-TYPE EXPERIMENTS: A POSSIBLE ARTIFACT?

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During a new Mizuno-type experiments series, we examine more deeply the possible artifacts. In particular, the electric power measurement was carefully studied . We found that the bandwidth of our usual Unigor wattmeter was not large enough to give a correct measurement of the inlet electric energy when the current is very disturbed. The results that we gave in ref. 2 (Sotchi -ICCF13) are therefore no more valid. However, we present here complementary experiments that allowed us to find again abnormal excess heat.

EXCESS HEAT AND ANOMALOUS SILVER CONCENTRATIONS ON THE SURFACES OF PALLADIUM CATHODES AFTER ELECTROLYSIS IN ACIDIFIED WATER

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At the March 2009 Salt Lake City conference of the American Chemical society, an experiment demonstrating excess heat was performed. Two cells in series were identical except for the electrolyte. One contained battery fluid electrolyte with H_2SO_4 (Sp.G. 1.265) and tap water, and the other contained battery fluid electrolyte with H_2SO_4 (Sp.G. 1.265) and heavy water. Bothe cells had Pt foils anodes and Pd foils cathodes. The light water cell (H) produced excess thermal power (about 1 W) compared with the heavy water cell (D). This was later confmned in oru‘ PSU laboratory. using more accurate calorimetry.

Scanning electron microscopy of the Pd cathodes revealed rimmed pits. The pits contained Ag. especially on tl1e H cell cathode surface. where 12 of 12 pits contained Ag. The Ag / Pd ratio in the spectra from these pits varied Hom 0.04 to 0.23. The average was 0.15. Ag was not detected in the rims surrounding the pits. Similar results were reported previously [1].

The present results cart be explained by our previous suggestion that thermalized neutrons are present. Absorption of these neutrons by Pd isotopes produces unstable isotopes which beta decay to form stable Ag isotopes [2].

It is noteworthy that excess heat was obtained using common, low-cost liquids, acidic battery fluid and tap water. This may signify the achievement of another step toward the goal of producing a practical. new source of energy.

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ANALYSIS OF EXPERIMENTAL RESULTS ON EXCESS HEAT POWER PRODUCTION, IMPURITY NUCLIDES YIELD IN THE CATHODE MATERIAL AND X-RAY EMISSION IN EXPERIMENTS WITH HIGH VOLTAGE ELECTRIC DISCHARGE SYSTEMS

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The identification of Low Energy Nuclear Reaction (LENR) processes in high-voltage Electric Discharge system (electrolysis cell experiment and glow discharge device experiment) will be reported. The experimental results are divided into three main branches: 1- Excess Heat production, 2- impurity nuclides yield (nuclear ash) production, 3- data on LENR triggering mechanism. At early stage we registered the Excess Heat with 5 – 8 W values and 170% Efficiency using the glow discharge device for operational voltage ranged 1000 - 1300 V [1]. These results are in good agreement with Excess Heat measurements obtained in experiments with Pd – D_2O high-voltage electrolysis at cathode-anode voltage up to 1000 V [2]. In confirmation and development of those amazing results we have designed a special cell powered by pulsed Glow Discharge power supply at electrolysis voltage of ~ 1000 V. Two sets of experiments were carried out at the following High Voltage Electrolysis operating parameters: Electrolysis in light water (H_2O) with a Ni cathode, Electrolysis in heavy water (D_2O) with a Pd cathode. The Excess Heat was detected in the experiments with H_2O – Ni and D_2O – Pd systems. The calorimetric system actual error was estimated using a resistive heater. The water-cooled flow heater was characterized by its own small specific heat and adequate thermal insulation. The obtained results are in good agreement with Excess Heat measurements obtained earlier in experiments with high-voltage electrolysis at voltage up to 1000 V and will be presented at ICCF-15.

The impurity nuclides yield (with changed natural isotopes ratio) registered in prior experiments by the following methods: spark mass spectrometry, secondary ionic mass spectrometry, and secondary neutral mass spectrometry [1].

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). In our opinion, future development of new nuclear engineering could possibly base on low energy nuclear reactions in the solids driving by high-voltage Electric Discharge system.

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INVESTIGATIONS OF CO-DEPOSITION SYSTEMS

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Experimental studies including cyclic voltammetry (CVA) and electrochemical impedance spectroscopy (EIS) were performed on several co-deposition systems. The palladium deposited onto a copper substrate for both the $PdCl_2$ + LiCl and $PdCl_2$ + NH_4Cl + NH_4OH solutions produced high capacitance values (100 Farads per gram of Pd) equal to those of supercapitor materials. These high capacitance values for the deposited palladium produced a collapsing and tilting of the cyclic voltammograms that approached Ohm's Law behavior. This behavior is predicted for large capacitance electrodes when using faster voltage scans.

The presence of protons as H^+ within the bulk of the deposited palladium forms a secondary double layer that likely contributes to these high capacitance values. Based on the electrode capacitance, it is estimated that the deposited palladium increases the effective surface area of the cathode by a factor of 10^5 or more. Because the excess power observed in co-deposition experiments scales much more closely with the palladium volume, it appears that the Fleischmann-Pons effect (FPE) is a volume effect in co-deposition systems and occurs within the deposited palladium metal rather than on the cathode surface or within the solution/metal double layer region. The secondary double layer within the palladium is likely a region rich in both electrons and deuterons and a prime candidate for near surface fusion reactions.

The main focus in these experiments was on the 0.025 M $PdCl_2$ + 0.15 M NH_4Cl + 0.15 M NH_4OH system because the deuterium analog produced excess power in three out of three prior experiments. Each Pd^{++} ion deposited is replaced by two H^+ ions, thus large pH changes occur (pH = 8.87 to pH = 1.25), along with the loss of NH_3. Chlorine evolution occurs while the solution peaks in acidity along with the related formation of nitrogen trichloride, NCl_3. The formation of NCl_3 is characterized by a yellow solution color, but this dissipates within one day of electrolysis at 100 mA. Although these chemical changes complicate the initial calorimetry, these reactions stop after the first few days of electrolysis. It is therefore recommended to keep the cell behind a safety shield with adequate ventilation and to wait until the chlorine evolution ceases and the system stabilizes before performing calorimetric measurements.

Experiments are in progress to determine the reproducibility of the FPE in various deuterated co-deposition solutions.

DIURNAL VARIATIONS IN LENR EXPERIMENTS

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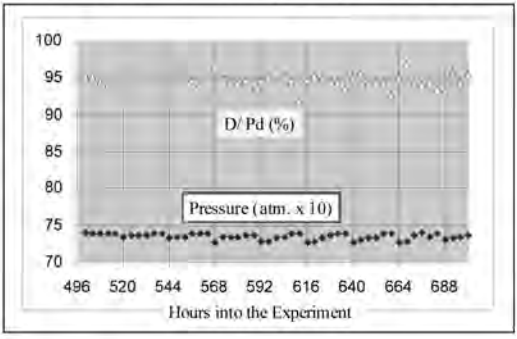
Experimental setups and protocols, and theoretical explanations of LENR, have been assumed to be independent of the time of day, that is, they have no diurnal effects. But, such effects have been measured by two of us. The figure shows daily Palladium loading and pressure cycles in an experiment in Hokkaido University, with points taken at four-hour intervals.



This paper presents and analyzes observed diurnal effects in two very different electrochemical LENR experiments in Japan and the USA. The goals of this paper are two-fold. The first is to determine if the observed effects are some kind of artifact or else real variations of a fundamental nature. Possible causes of diurnal effects are enumerated and analyzed. The second motivation is to exploit the observed variations, whatever their origins. The results could range from mere discovery of a new type of experimental error to the achievement of a remarkable new tool for cosmic ray studies.

If diurnal effects are artifacts, the measured dependence of the characteristics and outputs of LENR experiments on the time of day has implications for the proper conduct of such experiments. For example, it might indicate something about the temperature or light sensitivity of such experiments. Possibly, subtle and seldom-seen new sources of errors in LENR experiments would be illuminated.

If the effects withstand scrutiny, and appear to be defendable variations due to the rotation of the earth, then they might have astrophysical implications. That is, maybe the output of LENR experiments could be used as a relatively inexpensive detector for some types of extra-terrestrial particles. The reality of diurnal effects on LENR experiments could have implications for theories that seek to explain lattice-enabled nuclear reactions.

The ability to suppress, induce or enhance diurnal effects in LENR experiments might be a significant aspect of their controllability, which will be needed for commercialization of LENR. Desirable future work to verify and understand diurnal effects on LENR experiments will be described.

EFFECT OF PULSE FREQUENCY AND AMBIENT TEMPERATURE ON EXCESS HEAT TRIGGERING BY 532 nm LASER IN A D/Pd GAS-LOADING SYSTEM

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Based on the former works [1-5] a series of experiments on excess heat triggering by a 532nm laser were made with different loading ratio of 0, 0.1, 0.21, 0.29, 0.40 and 0.85 in a D/Pd gas loading system. The effects of pulse frequency of the laser and ambient temperature on excess heat were discussed. The results shown that there were 11 experiments in totally 60 that had obvious excess heat, which was nearly 17% of positive results. Otherwise the laser output with pulsed mode had a better effect in excess heat triggering than that in the triggering with the continuous mode.

In the range of pulse frequencies one pulse per second had the best positive results than that in the frequencies of 5, 15, 30 and 50 per second. The dynamic pulsed triggering produced more excess heat than that with static pulsed triggering. The maximum power density was 2.3×10^3 W/cm^3 Pd.

The effects of ambient temperature of 35, 50, 100 and 140℃on excess heat production indicated that the higher the temperature the less obviously the heat response. Statistics analysis suggested that there was a higher possibility (Y) on excess heat production at the loading ratio (X) of 0.7:

$$Y = -65.789X^4 + 101.97X^3 - 49.039X^2 + 8.4105X \qquad R^2 = 1$$

So the higher temperature might have a high corresponded loading. In this D/Pd gas-loading system higher loading than 0.6 will need a longer time to reach, so we have not got the data at that ratio yet. More endeavored work should be done in our next step.

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MECHANICS TRIGGERING: A POSSIBLE APPROCH TOWARDS HIGH DENSITY EXCESS HEAT PRODUCTION

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Twenty years have passed since Fleischmann and Pons announced CF phenomenon in 1989. Although there are more and more positive results both in experimental and in theoretical the mainstream science have not accepted this meaningful research in many aspects. One of the most principal reasons they deny the subject could be that there were no most obvious and strongest positive evidences for excess heat production and most convinced element transmutation. Especially there were less phenomena like “heat after death” with high power density as Fleischmann and Pons did in 1993, Mizuno in 1998 and Tian in 2002[1-3].

Unfortunately no one knows what induced that incredible phenomenon. And few people reduplicated that exciting experiment so far. Scientists worked in this field endeavor to find the way to repeat the process. They try to use every kind of triggering methods including heat, electricity, magnetic, ultrasonic, laser and so on. But a kind of method (not a new one) has not been paid for more attention for many years, which is mechanics triggering. As we all know in electrolysis systems we stirred the solutions with the help of bubbles. And in gas loading system we use electric fan to make the temperature field uniform. Besides these most of us do not think of it as a triggering factor too much.

In our studies we chose the pressure in gas loading system, rotation speed in the electrolysis as a triggering factor and find some interesting phenomena in some experiments. Take the former for example: sudden change of system pressure could bring a big temperature rise. And rotation speeds that were lower than 50rpm would cause an abnormal heat response in the latter. We could not introduce more here due to patent applying. We would like to make them open when ICCF-15 is hold in Rome this October.

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THE EFFECT OF POTASSIUM IONS ON ABNORMAL PHENOMENA IN Pt(H)-Pd ELECTROLYSIS SYSTEM

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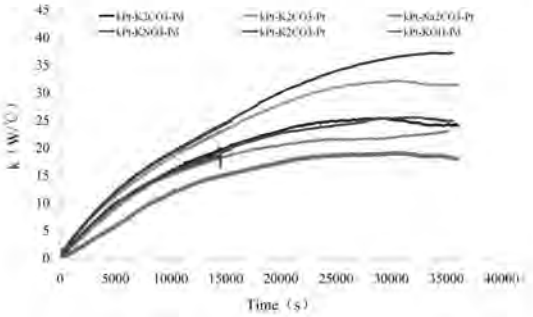
In condensed matter nuclear science research ordinary water has often been considered as a control for excess heat detection in D/Pd electrolysis systems. According to the former work[1,2] the variation of heat coefficient (k), potential of hydrogen (pH) and absorbency (A) of calcium ion in K_2CO_3, KNO_3 and KOH solutions before and after electrolysis were discussed here in order to find if there eventually were any anomalous effects both in excess heat and in transmutation. The experimental results are shown as in the following figure:



From the results we learned that there were excess heats of about 1.9×10^4J in K_2CO_3 electrolysis, 2.9×10^3J in KNO_3 and no abnormal heat in KOH. The differences of pH and absorbency implied that there might be a possible nuclear process [3] in them:

$$^{39}_{19}K+{}^{1}P\rightarrow{}^{40}_{20}Ca+8.33MeV \quad \text{or} \quad {}^{41}_{19}K+{}^{1}P\rightarrow{}^{42}_{20}Ca+10.3MeV$$

because some obvious changes of ΔpH=0.09, ΔA=0.12 were found in K_2CO_3 electrolysis, and ΔpH=0.11, ΔA=0.22 in KNO_3 respectively. No change in KOH.

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PROPOSAL OF AN EXPERIMENT AIMED AT CHARGING DEUTERIUM IN PALLADIUM AT THE TEMPERATURE OF LIQUID NITROGEN

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One of the most established features of the phenomenon known with the name of "Cold Fusion", with reference to the system palladium (Pd) – deuterium (D), is that a condition necessary (even though not sufficient) to be satisfied in order for these phenomena to take place is that the content of D in Pd, called also the D/Pd ratio X, approach the value of 1 (intending by this quantity the atomic ratio between the two species in the Pd lattice).

In order to reach such an high value of X, extensive use of electrolysis of heavy water with a Pd cathode has been made. An alternative line that has been followed by the author[1] consists of trying to obtain high values of X by the direct interaction of Pd with D_2 gas. In order to realize such a task, the following parameters have to be considered:

- temperature: X increases as temperature decreases;
- pressure: X increases as pressure increases;
- minimum linear size of the sample: diffusion regulates the distribution of D within the lattice of Pd, and the coefficient of diffusion decreases as temperature decreases; conversely using low linear size samples shortens the diffusion times;
- as a consequence of the latter, time becomes an important parameter when planning an experiment.

To give an idea, in the quoted experiment a value of X = 1 was obtained with a pressure slightly lower than 1 bar, at the temperature of 150 K, with a sample 3.6 μm thick. The time necessary in order to reach thermodynamic equilibrium for each absorption episode was in the order of one week.

The idea at the basis of this proposal is to have a much simpler experiment, able to run for a long time substantially unattended. It consists of using a sample of larger mass and lower dimensionality than the one used in (1), immersed in liquid nitrogen (LN2), and realizing a very simple calorimeter, so that the possible excess heat be the only parameter to be measured and recorded. The calorimeter will be described.

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EXCESS HEAT WHILE SATURATION OF TITANIUM BY DEUTERIUM AND AIR MIXTURE

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According to previously received data, during the saturation of titanium with deuterium and air mixture, temperature rising of 45 °C was registered for the titanium deuteride sample in comparison with a similar sample saturated with pure deuterium. A neutron flow of $1{,}68 \cdot 10^5$ neutron/sec was registered, which shows that excess heat is a result of nuclear reactions.
The calculation of excess heat based on the data is given. Possible nuclear reactions are considered.
The results are compared with the data on heat for uranium division and heat nuclear fusion. The magnitude of excess heat is shown to be less than that for uranium division or for fusion reaction between deuterium and tritium, but still more than the magnitude known for heat fusion reaction D + ^{17}O.

Neutron Spectra in CMNS
- Model Predictions and Past Data –

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The recent SPAWAR claim[1] on $^{12}C(n,n')3\alpha$ detection (triplet tracks) reminds our old discussion on observed neutron spectra from CMNS/CF cells in the past.
In our past experimental data[2-6], neutron emission rates were negligibly small (on the order of 10^{-10} or less) compared to excess heat events as regarded as nuclear origin, but observed neutron spectra having two (2.45MeV and 3-10 MeV higher energy) components provided us important information on underlying physical mechanisms of condensed matter nuclear effects (often called as cold fusion).

Explanation by the secondary d-t reaction after d+d fusion is not plausible, as the yield of d+t reaction by 1MeV triton slowing down in PdDx matter is on the order of 10^{-5} : One $^{12}C(n,n')3\alpha$ event needs about 100 fluence of 14MeV neutrons into a used CR39 track detector. This should correspond to 10^{7} neutrons of 2.45MeV by d+d reactions: This is easily to be detected as so many tracks, but has never been observed so.

[Case-1]: If "Dream Model" of the **"d+d to ^{4}He + lattice energy (23.8MeV)"** were taking place, the doping tritons make "d+t to ^{5}He + lattice energy" reactions, in the same path and, $^{5}He \rightarrow n(0.716MeV) + {}^{4}He(0.179MeV)$: **14 MeV neutrons are not major products**, but **low energy neutrons (0.716 MeV)** should be detected with micro-curie/cc-DTO-doping.

[Case-2]: Our **4D/TSC fusion model** predicts 23.8MeV/^{4}He energy deposit in PdDx lattice as major product. **Minor products of triton and higher energy neutrons** are predicted. **Neutron energy appears in 0.41 to 6.79 MeV (emitted from moving ^{5}He break-up) by (3D+T)/TSC fusion.** By $^{9}Be^{*}(43.01MeV) \rightarrow n + {}^{8}Be^{*}(Ex) + (41.36MeV- Ex)$, neutrons are emitted in 0-36.75 MeV region.

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LOCAL ABNORMAL PHENOMENA IN PALLADIUM TUBE HEATED IN DEUTERIUM GAS

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Excess heat is observed in a gas-loaded D/Pd system [1]. It's assumed in the Selective Resonance Tunneling Theory that nuclear fusion will occur when the deuterium is in the resonance states in the palladium lattice [2]. Experiments are designed to search for the conditions of the reaction.

A palladium tube soldered by two tubes, (ϕ4.0mm×147×0.1mm and ϕ2.3mm×388×0.1mm), is placed in a stainless steal tube, out of which is the uniformly electrical heater. Twenty thermal-couples (T1-T20) are welded in the palladium tube, the interval between each is 3cm.

Abnormal temperature rising is observed in locality area in the Pd tube (Fig.1). In the whole process, there is no unusual fluctuation on either side of the area.
By measuring the behavior of the temperatures around a electrical heater in the Pd tube with a determined length and determined power, the amount of the excess heat can be estimated; showing a total energy release up to 70J, that corresponds to an energy release of 13eV for each palladium atom.

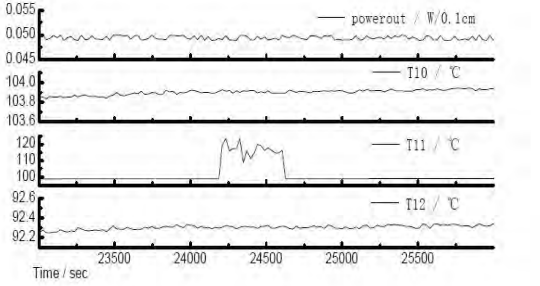

Fig.1 Abnormal temperature rising in Pd

Several abnormal temperature risings are observed in these experiments, whose character is similar.

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PIEZONUCLEAR REACTIONS IN INERT SOLIDS: NEUTRON EMISSIONS FROM BRITTLE FRACTURE

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The results of the present paper are in strict connection with those presented in a previous contribution recently published in Physics Letters A [1] and related to piezonuclear reactions occurring in stable iron nuclides contained in aqueous solutions of iron chloride or nitrate. In the present case, we consider a solid containing iron –samples of granite rocks– and the pressure waves in the medium are provoked by particularly brittle fracture events in compression. As ultrasounds induce cavitation in the liquids and then bubble implosion accompanied by the formation of a high-density fluid or plasma, so shock waves due to compression rupture induce a particularly sharp strain localization in the solids and then material interpenetration accompanied by an analogous formation of a high-density fluid or plasma.

Our experiment follows a different path with respect to those of other research teams, where only fissionable or light elements (deuterium) were used, in pressurized gaseous media [2], in fluids with ultrasounds and cavitation [3], as well as in solids with shock waves and fracture [4]. We are treating with inert, stable and non-radioactive elements at the beginning of the experiments (iron) [5], as well as after the experiments (aluminum). Neither radioactive wastes, nor electromagnetic emissions were recorded, but only fast neutron emissions.

Therefore, our conjecture is that the following piezonuclear fission reaction should have occurred in the compression tests on granite specimens [5]:

$$^{56}\mathrm{Fe} \rightarrow 2\ ^{27}\mathrm{Al} + 2n$$

The present natural abundance of aluminum (7-8% in the Earth crust), which is less favoured than iron from a nuclear point of view (it has a lower bond energy per nucleon), is possibly due to the above piezonuclear fission reaction. This reaction –less infrequent than we could think– would be activated where the environment conditions (pressure and temperature) are particularly severe, and mechanical phenomena of fracture, crushing, fragmentation, comminution, erosion, friction, etc., may occur. If we consider the evolution of the percentages of the most abundant elements in the Earth crust during the last 3 billion years, we realize that iron and nickel have drastically diminished, whereas aluminum, silicon and magnesium have as much increased. It is also interesting to realize that such increases have developed mainly in the tectonic regions, where frictional phenomena between the continental plates occurred.

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PRACTICAL WAYS TO GENERATE PROTONS (DEUTERONS) IN THE 500-1000 eV ENERGY WINDOW

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Ion generators, with kW level of energy, are now available on the market and extensively used in surface treatment and electronic industries. The technology of these ion generators will be described.
A prototype of such a generator has been built in the lab, using a glow discharge at a few hPa, generating (through a hole in the cathode) a deuteron beam impacting a target in a deuterium atmosphere at pressure less than 0,1 hPa. Ionic current of 600 μA have been achieved. The energy of the deuterons in the beam is estimated to be several hundreds eV.

The prototype will be described and its performances presented. It will be used to test the hypothesis that deuterons of energies between 500 and 1000 eV, impacting a metallic lattice loaded with deuterium, could generate sizeable amounts of fusion reactions, yielding energy production of industrial significance. [1]

[1] J. Dufour. ICCF15-DUFOUR-1

Enhancement of production rate of d-d reaction in deuterium-loaded metal with bombardment of α-particles from uranium decay

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In order to search for mantle ^{3}He source in the deep Earth[1], we designed experiments to create nuclear fusion at low temperature. In the previous work, we reported the experiment results for the deuterium-loaded titanium samples at room temperature. The production rate of d-d reaction in the metal matrices was deduced to be $(1.5 \pm 0.5) \times 10^{-24}$ fusions/deuterium-pair · sec[2]. In the present work, we tried to examine how ^{3}He, as a product of d-d reaction, D(d,p)T(β)^{3}He and D(d,n)^{3}He, might be correlated to the energetic α-particles , produced from natural uranium decay.

Two deuterium-loaded titanium samples were prepared, one is thick sample, a deuterium-loaded titanium (TiD) foil with a thickness of 0.1 mm and D/Ti atom ratio of 0.4, others is a thin sample, with 1.5 μm deuterium-loaded titanium film onto the surface of the molybdenum substrate (TiD-Mo foil), 20 mm in diameter and 0.5 mm in thickness, and D/Ti ratio =1.4. The two samples were also used for the previous experiment. The ^{235}U-source was prepared by depositing ^{235}U materials onto an aluminum foil (substrate) with thickness of 31 μm and diameter of 25 mm. The uranium layer has diameter of 20 mm and 0.910 mg/cm^2 of ^{235}U. The ratio of α-particles of ^{234}U to ^{235}U is 25. The Al substrate is also used for stopping the α-particles from the ^{235}U-source and for identification of charged particles exiting from the sample. The intensity of ^{234}U α-particle is 6500 Bq. The aim of this experiment is searching for proton from d-d reaction, i.e. d + d → p (3.02 MeV) + T (1.01 MeV). The results show that the production rate of d-d reaction are enhanced to $(2\text{-}7)\times10^{-21}$ fusions/deuterium-pair · sec, and average d-d reaction cross section for α-recoiled deuterons, resulting from collision between α-particles and deuterium atoms, is determined to be 4×10^{-19} cm^2 and 1.6×10^{-18} cm^2, for the TiD and TiD-Mo sample respectively. Thus, the deduced d-d reaction cross section for α-recoiled deuterons in the metal lattices is 6-7 orders of magnitude higher than the conventional d-d reaction cross section measured with accelerated deuterons, ~10^{-25} cm^2.

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X-RAY SPECTRA OF EXCITED LONG LIVING 0.6 – 6.0 keV ENERGY LEVELS FROM THE SOLID STATE CATHODES OF ELECTRIC DISCHARGE SYSTEM

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The experiments were carried out using a pulsed high-current glow discharge device, consisting of a water-cooling vacuum chamber, water-cooling cathode and anode units [1]. The X-ray emission has been recorded through a diagnostic window placed above the cathode. The discharge was initiated in H_2, D_2, Ar, Kr and Xe gas atmospheres at pressure in the range of 1 – 5 Torr using cathode foils of Al, Sc, Ti, Ni, Mo, Pd, Ta, W. The discharge current up to 200 mA, corresponding to voltages in the range of 3000-4300 V has been applied. The glow discharge was operated with specially designed pulse-periodic power supply [1]. The fine structure of X-ray spectra were detected using a bent mica crystal X-ray spectrometer and recorded on X-ray film.

The X-ray spectra were obtained both as the continuum bands with energies ranging from 0.6 to 10.0 keV, as well as in the form of spots caused by emission 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 discharge current switching off (during up to 20 hours afterwards). The X-ray emission energy bands were found to be correlated with the K – L and the L – N X-ray transitions. The X-ray spectra include the following bands: K – M_3 X-ray transitions of 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 and in case of the high intensity beam emission they turned into white color spots (due to solarization of the photoemulsion). The "solarization" is normally characterized a large density of X-ray irradiation of X-ray film or negative photographic material. The energy of the spots depends on the material of cathode sample. Note that all obtained experimental results showed 100% reproducibility.

In our opinion, these results represent direct experimental evidence of the excited metastable energy levels of 0.6-10.0 keV in solid state cathode material.

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Reproducible neutron emission from palladium deuteride during temperature cycling at high pressure and ultrasound action

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Emission of neutrons is a direct evidence of nuclear reactions at low energy. First experiments in which neutrons release has been detected during gas-loaded titanium heating [1] were poorly reproduced. Contradictory data on neutron output were obtained also in electro chemical experiments with palladium cathode and during heating of deuterided palladium. A high-sensitive detecting system and specialized measurement method were developed in a deep underground tunnel to reduce cosmic rays and to secure high-reliable data [2]. Strong evidences of neutron emission up to 57±13 cts/hour from partially deuterided titanium subjected to non-equilibrium conditions were obtained. We developed earlier a method and devices for producing free neutrons and energy [3, 4] on the base of computer modeling of nuclear fusion in metal crystal structures [5] and on our experiments results [6].Intensification of nuclear fusion was reached at the expense of temperature circling at high deuterium gas pressure of fine crystalline metal-deuterides which have coexisting isostructural crystal phases with dissimilar deuterium content. We present in this report results of experiments by the use of simultaneous additional activation of nuclear process employing ultrasound piezogenerator on the base of barium titanate with the resonance frequency 5 MHz. A prepared fine crystalline palladium powder less than 100 nm in size and 198 g mass was placed into reactor with the volume 300 cm^3. After several days of outgasing approximately to 100 millitorr, deuterium gas was pressurized up to 3 atm. Joul heating up to 400C was carried on with a wire furnace arranged inside the internal reactor tube. Neutron emission rates were measured every 150 seconds by spectrometer with ^{3}He-detector. An additional paraffin screen 55mm thick was arranged between the reactor and the spectrometer. The temperature was changed on heating with the rate 2 K $s^{-1}$and on cooling - 3-4 K s^{-1}. Runs extended over 80 -90 minutes. The background was measured before and after every run. Counting rates were found in all experiments on average 1.7 – 2 times higher than the background level. Maximal counting rate took place at cooling sometimes exceeding 2.5 times the background level. It correlated with intensity of deuterium sorption into palladium. Taking into account efficiency and the position of the detector relative to the reactor, a neutron emission rate from palladium deuteride during experiments was on average $10^2 – 10^3$ n s^{-1}. The mean background level was 0.015±0.003 n s^{-1} cm^{-2}. The results found are compared with data of other authors. The reasons of high neutrons emissions are discussed.

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LITHIUM FLUORIDE X-RAY IMAGING FILM DETECTORS FOR CONDENSED MATTER NUCLEAR MEASUREMENTS

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Lithium Fluoride, LiF, is a radiation sensitive alkali halide material well known as dosimeter and as active medium in light-emitting devices and lasers. Point defects can be produced in LiF crystals and films [1] by different kinds of radiation. Some of these electronic defects, known as colour centres, are optically active, with broad absorption and emission bands in the visible spectral range. Novel thin-film imaging detectors for soft X-rays, based on photoluminescence from aggregate colour centres in LiF, have been proposed [2] and are currently under development [3], successfully extending their operation also in the hard X-ray region, up to 10 keV [4]. Recently their use was proposed and preliminarily tested to obtain the image of radiation emitted from a nickel film hydride loaded by electrolysis, under light coupling with an He-Ne laser [5]. Among the main peculiarities of LiF-film based X-ray imaging detectors, there are an intrinsic high spatial resolution, a large field of view and a wide dynamic range. Moreover, they are easy to handle, as insensitive to visible light and no development process is needed. After exposure to X-rays, the latent images stored in the LiF thin layers are read by advanced optical fluorescence microscopes, with typical spatial resolution below 300nm. These detectors can be applied in photonics, biology, material science, and in the characterization of intense X-ray sources. They allow great versatility, as they can be grown in the form of thin films by well-assessed physical deposition techniques.

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COMPARISON BETWEEN PIEZONUCLEAR REACTIONS AND CMNS PHENOMENOLOGY

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Piezonuclear reactions have been theoretically foreseen and studied in the framework of a theory that deals with Local Lorentz Invariance (LLI) breakdown by introducing a microscopically deformed space-time [1]. According to this theory, new types of nuclear reactions can be induced also in stable medium-weight or heavy nuclides. The condition for these processes to take place is the release of an amount of energy to the nuclear system higher than an energy threshold of 367.5 GeV in a suitable interval of time. Some details of the theory will be briefly presented. The phenomenological mechanism that we used in our experiments in order to fulfil these two requirements is cavitation and more precisely bubble collapse brought about by ultrasounds [2]. It is necessary to point out that our theoretical, phenomenological and experimental research has nothing to do with sonofusion [3]. We cavitated solutions of different concentration of Iron wherefrom we obtained neutron bursts. Three different techniques were used to detect them: bubble detectors, CR39 screened by Boron and Boron Trifluoride. All of these techniques provided compatible results. The difference between neutron signal and the background-noise was more than 13 standard deviations [5]. Moreover, Boron screened CR39 were irradiated by neutrons from a nuclear reactor in order to produce tracks on CR39 plates able to provide a clear term of comparison. The tracks on CR39 irradiated during experiments of piezonuclear reactions are compatible with the former with some slight distinction which will require further investigation. Other evidences from these experiments are the lack of gamma rays, that are usually concomitant with neutrons, the existence of a threshold in time for neutrons to be emitted and the presence of Iron as key nuclide [4,5]. As to the lack of gamma rays, however, more extensive and refined investigations will have to be carried out since, although the theory, on which piezonuclear reactions are based, can explain (so far only qualitatively) the absence of concomitant gamma rays with emitted neutrons, prompt gamma rays produced by the interaction of neutrons with the surrounding medium (water) are indeed expected to be present. Besides, several evidences of transmutations during cavitation of water were obtained as well, but we shall not comment on them [6,7,8]. We will carry out a mere comparison of these "anomalous" results with those "anomalous" alike found in LENR-CMNS experiments. Finally, on the basis of such a comparison, we shall briefly wonder whether this alikeness of mere experimental results, obtained by so different experimental setups, might hide some common microscopic mechanisms in such unlike apparatuses and experimental procedures. The hypothesis will be put forward that the two conditions mentioned above as the key features of piezonuclear reactions might take place in LENR-CMNS experiments as well and might contribute to generate what is commonly referred to as nuclear active environment (NAE).

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EVIDENCE FOR FAST NEUTRON EMISSION DURING SRI'S SPAWAR/GALILEO TYPE ELECTROLYSIS EXPERIMENTS #7 AND #5, BASED ON CR-39 TRACK DETECTOR RECORD

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We have reported [1] the detailed analysis of the CR-39 detector (Landauer) from SRI's #BE013-7 (#7) Pd deposition experiment where the detector was separated from the cathode wire by a 6 μm Mylar® film during. The Mylar® protected the CR-39 surface from chemical, mechanical, and electrostatic (spark discharge) damage during electrolysis. We compared those results with that of the background detector (placed 2 m from the electrolytic cell) and with the blank CR-39 detector, installed as in #7, in an identically operated cell using light water. We also calibrated our CR-39 detectors using the proton recoil tracks from a Cf-252 neutron source and compared them with the foreground tracks. The readings were performed manually using the "PAVICOM" track reading facility in the Lebedev Physics Institute, Russian Academy of Sciences, Moscow, Russia. All detectors were cut from the same sheet.

We analyzed a 1.0 cm^2 area on both the front (facing the cathode) and rear face on all detectors. The area read on the Foreground #7, Background and Blank #16 detectors was S= on each side. The blank detector contained a total of 11 tracks cm^{-2} in the diameters of interest (4.0< d< 8.0 μm, t = 7 hr etch), similar to that found on the Background and unexposed detectors. Hence, we conclude that the blank detector has been neither exposed to neutrons in electrolytic H_2O cell nor irradiated by neutrons in airport security facilities. The entire data set obtained from the analysis of the #7 detector set, including 1) measurements at three removed depths (8.7, 18 and 27 μm), 2) comparison of track densities and diameters from D_2O, H_2O, and blank experiments, and 3) neutron rate and energy calibrations using Cf-252, present preliminary evidence for fast neutron emission ($E_n \sim 2.2 – 2.5$ MeV, $I_n \sim 1$-3 n/s).

The Foreground (#5, D_2O) CR-39 and corresponding Blank (#15, H_2O) detectors had a 60 μm polyethylene film adhered to both faces while immersed in the electrolyte and in contact with the cathode during electrolysis. Although it was necessary to etch the front face of detector #5 to > 25 μm due to chemical, mechanical and electrical discharge damage, the rear face showed proton recoil tracks similar to those found on both faces of the detector #7 (with a track density 50 -70% of that of #7). We conclude that detector #5 showing traces of weak neutron emission from the cathode during electrolysis, even though there was some non-nuclear induced attack on its front face.

In sum, our CR-39 results present evidence for fast neutron emission ($E_n \sim 2.0$-2.5 MeV) during SRI's SPAWAR-type PdD_x electrolytic co-deposition experiment. Additional high efficiency neutron measurements with other types of detectors would be desirable is necessary for independent confirmation.

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CHARACTERIZATION OF MATERIALS BY MEANS OF LASER-BASED TECHNIQUES

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Laser-based techniques are more and more used in the field of materials processing and analysis.

In particular, laser spectroscopic techniques as the Laser Induced Breakdown Spectroscopy (LIBS) and Laser Induced Fluorescence (LIF) have been applied to investigate the chemical-physical properties and the morphological structure of several kinds of materials. Some results in different fields of application are reported.

SONOFUSION; Ti TARGETS AND T

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There are three points of interest regarding sonofusion and Ti foil targets that may not be related to each other but add to our understanding of SF tech. These are the measurement of tritium, the colorimetric imprint via TiO_2 target surface of induced standing waves and their intensities, and the production of long 1µm diameter thin-skinned tubules of Ti resting on a target foil surface.

Tritium was identified as a product of sonofusion measurements by mass spectrometry. Experiment 4-2 is one selected from a series of analyzed sample volumes. The exposed Ti target foil, 5x5x0.01 cm, in a controlled flow of D_2O at 200 ml/min was cavitated for 18 hours. The 200 watt acoustic input into a 30 cc reactor volume was driven at 20 KHz by a Heat Systems 5 cm diameter Ti horn. The steady state temperature was 61°C, the external pressure of Ar was 30 psia. The configuration of the dual concentric cavitation reactors, the base reactor, had an H_2O cooling flow of 800 ml/min that was powered by a 550 watt Ti horn. The smaller top reactor and its target foil had a flow of 200 ml/min of cavitating D_2O. The input acoustic power for the top reactor was coupled and transferred through a stainless steel separation and interface disk, 0.1 cm thick and 9 cm in diameter. In the experiment above, the cavitation running time of18 hours produced initial T atoms that extrapolated to $3.7x10^{15}$ before any leak possibility.

The DOE's Brian Oliver, using his tested methodology for ^3He analysis, did the mass spectrometry. The gas samples were collected by vacuum transfer in evacuated 50 cc stainless steel sample volumes. Sample 4–2 was collected at the end of the run on 28 April 1994. All these dates are very important for measurements as $T \rightarrow {}^3He + \beta + v$ at a decreasing rate of ^3He appearance. The appearance of ^3He in the sample volume was based on the first order disintegration of the initial T. The first analysis was on 12 June 1994 and the second was on 16 Feb 1995 allowing time to pass between gas sample volume analyses. The results of these measurements show a disintegration constant that was consistent with the decay of T to ^3H. The plot of this data showed the rate of decay of T in the sample volume to be $d(To - {}^3He)/dt$.

The standing wave imprint observed in the 46 KHz opposing stack piezos reactor with a Ti target foil was intensely colored. The reactor had a controlled flow of 70 ml/min, a steady state temperature of 98°C, an external pressure of Ar at 51 psia, an input acoustic power of 60 watts, and a cavitation running time of 24.5 hours. The visual wavelength of this standing wave is 2 to 3 mm wavelength and depended on the foil shape, its thickness, and its density. Imprinted cavitation exposed 100 µm thick foil surface in the 20 and 46 KHz sonofusion systems showed little ejecta site surface damage. Effects of a standing wave induced in the partially bound foil were easily observable. For Ti target foils the standing wave appeared as a surface modification in the form of TiO_2 molecular layers of varying thickness depending on the foil's surface standing wave node energies. The TiO_2 thickness was noted by the rainbow-like distribution one finds looking at an oil slick.

The observed difference between Ti and Pd target foil's SEM photos at 20 and 46 KHz was the absence of ejecta sites in Ti foils. SEM photos by Lorenza Moro, showed long hollow 1 µm in diameter tubules of Ti close to the surface of the Ti target foil. They appear as a few atoms of Ti skin hollow tubes with a pure Ti composition where melted Ti was forced out. John Dash has observed similar tubules in Pd.

INVESTIGATION OF RADIATION AND TRANSMUTATION PROCESSES AT BUBBLE CAVITATION IN SUPERSONIC FREE WATER JET

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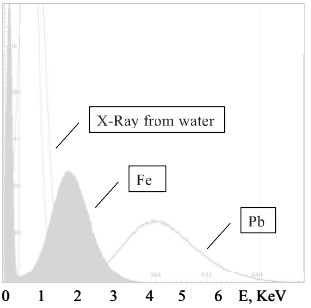
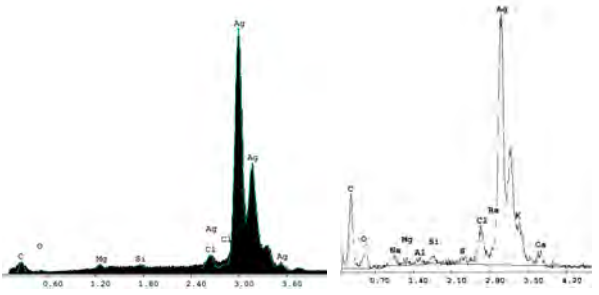
[2]*Kiev National Shevchenko University, Kiev, Ukraine*

In the work [1] both optical and weak X-Ray radiation phenomena accompanying cavitational processes at directed motion of running machine oil through thin dielectric channels to hermetic cavitation chamber were investigated. The mechanism of X-Ray generation was connected with the tandem of cavitation and shock-wave processes. In the present work the results of investigation of intensive X-Ray radiation connected with bubble cavitation phenomena in supersonic water jet in free space and near the end of water output channel are presented and discussed. We have investigated bubble cavitation and X-Ray generation phenomena at super-high pressures of water (from 200 atm up to 3000 atm). The soft part of X-Ray radiation ($E_X \approx 1$ keV) was generated by the surface of supersonic free water jet in the area of cavitation at any pressure. The energy of radiation from the surface of water output channel (made of stainless steel) was $E_X \approx 2.0$ keV. In the case of additional lead cover on this stainless steel surface the energy of X-radiation was $E_X \approx 4.5$-5 keV (see Fig 1). The total activity of X-Ray generation was about 0.1 Ci. The same radiation phenomena were detected by X-Ray photo-plates. From the other hand it was shown that in such water output system with intensive cavitation the process of tandem formation of controlled (focused or directed) laser-like X-Ray radiation beams is possible.



Additional experiments were connected with the investigation of the possibility of cavitation driven nuclear synthesis. We have conducted a lot of experiments in the area of interaction of supersonic cavitating water jet with the surface of condensed matter. In Fig.2 the results of change of pure Ag (purity 99.99%) chemical composition before (left) and after (right) the interaction with pure cavitating water jet at P=2000 atm are presented. The problem of isotopes transmutation in the area of cavitating water jet with surface interaction is discussed.



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Erzion Model Interpretation of Oriani Results in CR-39 Films, our IPRIM Results Received at the Anode Plasma Electrolysis in Water Solutions & Baranov Results on Bi^{212} Generation from Bi^{209} by Erzioatom Introduction

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To explain Oriani & SPAWAR experimental results in CR-39 films [1] and also our abnormal experimental results received at the electrolysis with gas discharge on the anode in IPRIM [2] it was proposed their Erzion model interpretation [3]. In framework of EM [4] nuclei of the hydrogen (in Oriani case) or oxygen (in IPRIM case), being Enions carriers, dump Enions inside of the electrode during the electrolysis where they are converted into neutral Erzions with large energy up to ~ 1MeV, leaving a cell outside. Neutral Erzion in organic material of CR-39 films on the nuclei of group (H,C,N,O) creates catalytic Erzion-nuclear chain of exothermic reactions. In view of high Erzion mass practically all energy of reaction is transferred to recoil nuclei, but Erzions are created with very low energy (~10keV) and consequently with small length for nuclear interaction (~30 microns). Tracks in all thickness of a film are caused by recoil nuclei with energies ~ (1-2) MeV with the big specific ionization (~MeV /mg/cm^2) and small length (~2-5 microns). In total in such clusters in all volume of a film it is expected ~ (10^3 - 10^6) tracks with a cluster's size ~ (100-1000) microns. In the case of IPRIM results of regular reproducibility of large neutron flux registration by radiometer RUP-1, not confirmed by In neutron activation analysis with help of Ge-detector & NaI (Tl) scintillator results can find their explanation in framework of Erzion model with their imitation by neutral Erzion reactions in organic composition of scintillator detector. In framework of Erzion model (EM) [4] it is proposed the interpretation of Baranov results of Bi^{212} generation from Bi^{209} nuclei [5]. In framework of EM it is possible on the base of negative Erzion creation of alone neutral Erzioatom (Triton-Erzion - $\{Э^-,H^3\}$), which has on its orbit super heavy Hydrogen isotope nuclear – Triton. More light Hydrogen nuclei (proton & deuteron) have nuclear exothermic exchange reactions with $Э^-$ and haven't enough time to create long-lived Erzioatom. Bond energy of such Triton-Erzion - ε~100 keV and it's size - R~10 fm. 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 with large release energy, which can go not only for recoil energy but also for excite energy, that can be easily experimentally checked.

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Procedure for Evaluating Theoretical Papers on LENR

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We have developed a procedure for evaluating the potential usefulness of each particular theory on the mechanisms active in LENR experiments, based on a specific set of criteria. In order to identify the character, limitations and potential applicability of each theory, and to determine the relationship of the theory to other theories, we first summarized the content of the theory. Then, we formulated a set of questions, involving specific requirements. These seem to be necessary for the theory to be useful. The particular questions that we identified are: 1. What is the form of the reaction (if any) that is addressed; 2. How does the theory treat the Coulomb Barrier (if the theory addresses this); 3. Has the theory been written in a way involving equations; 4. Have the equations been reduced to numbers for some cases (or for any case); 5. Can anything be said about computational results, associated with the theory. In addition to addressing these questions, we reviewed each pf several theories, based on the more conventional manner, which is frequently used (summarizing the theory, how it is related to the field and to conventional science, and identifying shortfalls in the presentation). Given the nature of the field, many different theoretical ideas have been proposed, and for this reason, attempting to evaluate the merits of the various theories has been a formidable task. In adopting the procedure that we have used, we are hopeful that a useful synthesis of the various ideas will become possible. In the paper, several of the more important ideas are summarized, and common themes, involving all of the papers are identified.

SIMULATION OF PALLADIUM TRANSMUTATION PRODUCTS

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The transmutation of nuclear species was discovered in 1938, but nuclear theory has been ***unable*** to explain the asymmetrical (3:2) masses of the fragments produced by the fission of the actinides. Despite decades of theorizing, most specialists on fission frankly agree with Moreau & Heyde [1] that "the theoretical description of the fission process is the ***oldest problem*** in nuclear physics, [but] it appears that a consistent description is still very far away."

We have reported, however, that a lattice model of nuclear structure [2, 3] – essentially, a "frozen" liquid-drop that is mathematically identical to the standard "independent-particle model" (IPM) – predicts the asymmetrical fission fragments produced by the thermal fission of uranium [4, 5], ***without*** using any "adjustable parameters" to produce the asymmetry (Fig. 1). This theoretical result (and that concerning Palladium, below) can be verified using the *Nuclear Visualization Software*, available at: http://www.res.kutc.kansai-u.ac.jp/~cook.

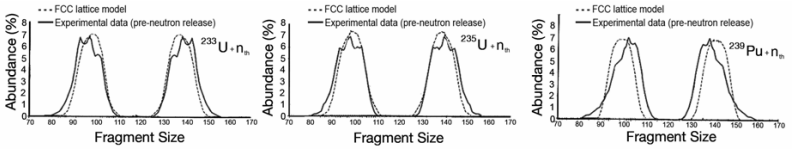

Fig. 1: The prediction of asymmetrical fragments in the thermal fission of the actinides [4, 5].

Here, we apply the ***same*** lattice technique to the fission of the 6 stable Palladium isotopes. By calculating the total binding energy across each scission plane minus the Coulomb repulsion between the fragments, the lowest energy fission events in each of 6,000 randomizations were obtained. Most fragments are stable or lead to rapid β^--decay, with a predominance of ^{22}Ti and ^{24}Cr final products and little ^{23}V, qualitatively similar to the spectrum of deposits on Pd, as reported by Mizuno [6] (Fig. 2b, c). We conclude that the substructure provided by the nucleon lattice is a necessary addition to conventional nuclear theory in order to explain the products from both the thermal fission of Uranium and "cold fusion" nuclear transmutations.

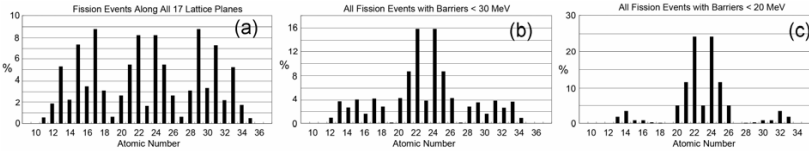

Fig. 2: Parameter-less lattice model prediction of transmutation products following Pd fission.

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Self-Polarisation of Fusion Diodes : Nuclear Energy or Chemical Artefact?

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The cold fusion community has been trying to justify cold fusion on the basis of empirically produced excess heat for nearly two decades. The science world has continually resisted the possibility, citing the heat as not conclusive.

The authors have sought a different approach, whereby the device has no input energy, relying on the only energy produced from the device. The diodes are fabricated as powder diodes, with a large surface junction made up of a semiconductor in contact with palladium charged with deuterium.

The suspected fusion reactions take place in the junction between the semi conductor and the Palladium powder, which produces an excitation which is transmitted to the electrons. This excitation increases their energy and allows them to cross the bandgap of the semiconductor and pass into the conduction band, as in a photovoltaic cell. This energy very quickly appears as a spontaneous potential difference which can reach over 0.5 volt per junction.

Diodes comprising of a stack of junctions were made, making it possible to obtain over 1 volt at the poles of a very compact device of a few centimetres length. The released power remains very low for the moment, but it should be noted that it is presented in the form of directly usable electrical energy, and not of thermal energy.

Is the observed release of energy due to the fusion of the deuterium nuclei, or is it an electrical voltage produced by an electrochemical reaction? The authors discuss the origin of the energy measured over several months with the help of various methods.

ISOMORPHISM – STRUCTURAL UNITED UNIVERSE

F.A. Gareev[1], **G.F. Gareeva**[1] **and I.E. Zhidkova**[2]

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We propose a new mechanism of LENR and cold fusion: cooperative resonance synchronized processes in the whole system, nuclei+atoms+condensed matter+enviroment, can occur at smaller threshold energies than the corresponding ones on free constituents.

We came to the conclusion that the channel motions in physical systems and electron motion in the ground state of a hydrogen atom are exactly synchronous. The isomorphism properties of hydrogen atom and other atoms, molecules, crystals, water, DNA, living molecules, Earth and solar system was established.

In our talk we will bring arguments that the forms of physical systems similar to the forms of Platonic bodies. Therefore, the same structures have cosmic space.

NEW MECHANISM OF COLD FUSION REACTIONS

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New mechanism of cold nuclear fusion reactions is proposed by Yu.L. Ratis [1, 2] and it is completely in co-operation with known fundamental laws of physics. It is shown, that neutral nuclear active composite particles due to which revising the cold fusion reaction present bound state of two neutrons and single neutrinos. These particles called "dineutronium". They are exotic neutron atoms and participate in nuclear reactions.

Dineutronium atoms are metastabile. The time of dineutronium D_ν life in the low energy region of strong interactions is equal to 10^{-3} c and is essentially greater than the life time of ν. The decay channels $D_\nu \to n + anything$ closed down in such cases.

The sizes of dineutronium atom are commensurable with the sizes of deutron and its mass is equal to $M_{D_\nu} = 1876.0979650\ MeV$.

The dineutronium generation reaction $D(e,e')D_\nu$ in gaseous deutron have the threshold $E_{tr}^{gas} = 14.86\ eV$ and the cross section is equal to $\sim 10\ mbar$, the corresponding threshold in condensed matter $e^- + d \to D_\nu + phonon$ is equal to $E_{tr}^{cm} = 1.27\ eV$ and cross section $\sim 1 mbar$.

The proposed model described:

a) the abundance of the tritium in Nature;
b) the ration T/n in the low energy nuclear reactions ($T/n \sim 10^9$);
c) the production of exceed heat and helium in the experiments of Arata Y. and ZhangY.-C.;
d) the output of I.C. Filimonenko's reactor.

The some revision introduced to Mendeleev's Table. It is shown that in the Periodic Table the
dineutronium allocated following the neutron in zero row in the zero period.

The great life time, small sizes, electrically neutrality and great cross section in reaction $e^- + d \to D_\nu + X$ allow to participated dineutronium atoms in nuclear reactions with the surrounded nuclei. Therefore the synthesis of dineutronium atoms can be economic and energetic point of views justified [1, 2].

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THE CURRENT SCIENTIFIC REVOLUTION IN PHYSICS AND ECONOMIC CONSEQUENCES

Edward Lewis

USA

As was described in earlier ICCF10, ICCF11, and ICCF14 proceedings, the history of science shows that scientific revolutions have happened in physics at about every 80 year interval since 1506[1]. A theory was presented explaining why this periodicity is a function of the constraint of age and experience in acceptance of new theory, along with several other factors. It was shown that this theory also allows accurate economic predictions, since industrial revolutions coincide with the eras of scientific revolutions. The past three industrial revolutions were associated with economic depressions or deep recessions, and technological acceleration economic depressions followed these industrial revolution depressions about 30 years after the end of the industrial revolution depressions. So it was predicted that a 1930 style financial crisis and economic depression or deep recession would begin at the end of this decade, since the last major recessionary period ended about 1982. That it did, actually points to the accuracy of the scientific revolution model, since the economic model is based on this theory of scientific revolutions. The cold fusion and anomalous science research seems to have turned a corner in publicity this Spring of 2009. Perhaps, more funding will allow elucidation of the major anomalies that have been found of micro ball lighting, previously unknown atomic behavior and state, etc. If this happens, then in the next twenty years we may predict that there may the beginnings of new profitable industries based on this research, and the theoretical development of two kinds of theories.

It is predicted, based on the experience of the past scientific revolutions, that a new paradigm model will emerge that is based on these newly discovered phenomena themselves, not on quantum mechanical ideas. It is also predicted that the quantum theorists will continue to develop their theories in response to the new phenomena. This has always happened during scientific revolutions. Young and/or inexperienced men have formulated theories on radically new ideas, as did Einstein in 1905 and Faraday in 1820 and Franklin in 1745. At the same time, older and experienced scientists continue to develop their understanding which was based on the previous paradigm. During the 1800s, fluid based theories based on the Franklin paradigm were developed and accepted after the 1820s in most of Europe. Partly through the work of inventors who accepted these revised fluid theories, during the thirty year industry after 1820, the telegraph industry became an important industry. But it wasn't until Classical Field theory was well developed that major industries emerged. It was likewise for the industries based on Fluid theory and those based on Quantum Mechanics. It was 20 years after the theories of those paradigms were well developed that industrial revolutions began to happen. This recurring pattern allows us to guess that the industrial revolution based on this new paradigm won't happen until about 2052. However, there is still profit that may be made in the next few decades.

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NUCLEAR AND ELECTRONIC STRUCTURE OF ATOMS

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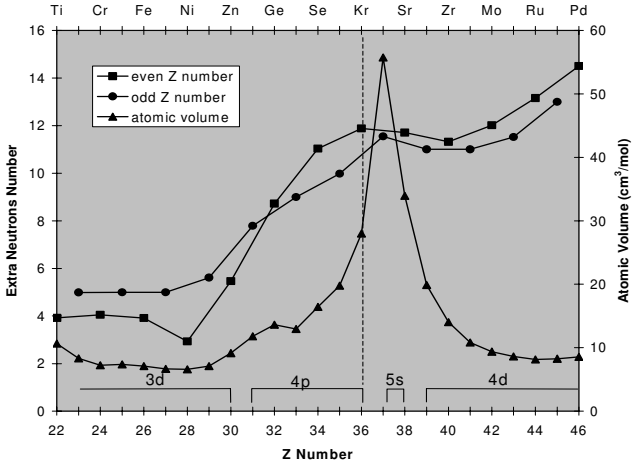
It is accepted that nuclear do not influence the electronic structure of atoms. The nucleus only provides a central positive charge to attract negative electrons. A plot of natural elements, with increasing Z number in abscissa, and the number of Extra Neutrons (EN=A-Z) of each natural element isotope as ordinate, shows periodicity in the trend of EN addition to the nuclei. The latter coincides with that of chemical elements properties reflected in the electronic structure and marked by the electron/proton numbers of noble gasses.

The above is experimental evidence, data are from [1], that nuclear architecture directs the electronic structure of atoms. The figure shows: the pattern of EN addition to nuclei; the electronic structure of atoms with shell principal and orbital angular-momentum (letters) quantum numbers; the atomic volume of atoms [2]. The weighted mean of EN added to stable isotopes of each element is used. Fading of these correlations for elements beyond Z number 65 will be discussed.

Of the different periodic tables [3] that suggested in 1929 by the French biologist/geologist Janet [4], with eight in place of the classical seven periods format, provides the best accordance with the periodicity of EN addition to nuclei.



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CHARACTERISTIC FREQUENCIES IN CMNS

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Most of physics is a study of resonances. Condensed Matter Nuclear Science is no exception. However, CMNS has resonances from the meV to the GeV level involving effective masses from photons, to phonons, to the electron, and to the alpha particle. These resonances are often referred to in terms of wavelengths (e.g., deBroglie and Compton) and are used because they often give the correct order of magnitude, but with no real understanding of why or how they apply. This presentation is intended to give both experimentalists and theoreticians something get hold of and make useful in the search for understanding the basics of CMNS.

Our starting point is the unique property of photons ($E = h\nu$) that gives an identity of frequency ν with energy. This of course leads to the photon's wavelength $\lambda = c/\nu$. Using the Einstein relation, $E = mc^2$, extends these relations to the Compton wavelength $\lambda_C = h/mc$. Thus, λ_C is just a measure of the mass of a body. But, it gives a useful size as well. Recognizing that "mc" looks like the momentum of something with mass m traveling at the speed of light c and that Bohr had quantized the angular momentum of the hydrogen atom in these terms, deBroglie suggested that $\lambda = h/mv$ would be a useful unit. λ_{dB} not only gave the circumference of the electron orbitals around Bohr's atom, it sometimes gave a useful measure of a body's velocity and its conserved momentum. However, this term is often misunderstood and therefore misused.

Part of the misunderstanding about the Compton and deBroglie wavelengths is related to the fact that frequency, not wavelength, is fundamental. Frequency is identified with energy, which is conserved. Resonant frequencies combine: $\nu_{\pm} = \nu_1 \pm \nu_2$. Thus, if we take a body with rest mass m and give it a velocity v it will have related frequencies of ν_C and ν_{dB} and an energy of $E_t = h(\nu_C + \nu_{dB}) = h(\nu_t) = m_t c^2$. (What happens to the beat frequency $E_? = h(\nu_C - \nu_{dB})$?) Since ν_t has increased and c is a constant, we see that the mass of the body has to increase with its kinetic energy. No matter how many bodies and their kinetic energies are added together, the sum of their frequencies is a useful quantity. The wavelengths may also be combined (albeit, in a more complicated manner); but, they do not have the intuitive feel that sums of frequencies have. Nevertheless, people use these wavelengths as if they understood what they represent. What they don't understand inhibits them from seeing options presented.

With this background, we intend to explore the resonances involved in the H^+H^+ (D^+D^+) tunneling process (a resonance phenomenon) and show how this becomes a catalytic process, which greatly enhances fusion probability. The available resonances in the excited compound nuclei and its environment determine the most probable decay paths as they seek their lowest energy levels. It is hoped: that this exercise will be able to convey the physics of the CMNS reactions and not just appear to be mathematical games; that the experimentalists will sharpen their intuitive feel of the real world; and that the theoreticians will be better able to apply their quantum mechanics to the problem, so that those who are not irreconcilably blocked can see the basis for CMNS.

Bose-Einstein type D-cluster Electrode Development

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Our recent research has developed a technique for imbedding ultra high density deuterium "clusters" (D cluster) in Palladium (Pd) thin film. Experiments have shown that in Pd these condensed matter state clusters approach metallic conditions, exhibiting super conducting properties. [1] This deuterium cluster has been achieved through electrochemically loading-unloading deuterium into a thin metal film, such as Palladium (Pd). During the loading process, Palladium lattice expands significantly due to invasion of deuterium into the interstitial sites. With the large enough stress, some linear lattice imperfections, called dislocations, form at α/β transformation interface. These dislocation defects form a strong potential trap causing deuterium to condense.

The dislocation formation can be further improved by metal surface modification. [2] With a thin oxide layer formed on top of Pd thin foil, the density of dislocation loops becomes higher at the interface between Pd and PdO than at the bulk Pd because PdO provides constrains on Pd lattice during hydride cycling and prevents dislocation annihilation at the free surface. Using Temperature Programmed Desorption TPD system, the local concentration of hydrogen in the dislocation core is found to be [H]/[Pd] ~ 1.8. At near 70 ºK Pd foil with abundant D clusters also show class II superconductivity, indicating the trapped hydrogen condensed into a metallic-like phase. [2] Room temperature cluster formation is found to be adequate for the desired "nuclear reactive" sites. By careful calculation and experimentation, it is found the D cluster has a Bose Einstein Condensation state when a high deuteron diffusion flux is triggered. The resulting momentum transfer initiates reactions. [3] The trigger can be either electrochemical, giving LENR reactions, or pulsed compression, as in inertial confinement fusion (ICF). Thus this configuration can provide a small LENR power cell or be as an improved non-cryogenic ICF target with very high reaction rates. [4, 5]

Currently, we are searching for new methods to improve the volume density of dislocations. These methods mainly involve modifying Pd thin film with multi-layer structure. A new specially designed TPD system for hydrogen desorption measurement is under development to expedite the search for best processes. The progress will be reported in the presentation.

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A POSSIBLE MECHANISM FOR COLD FUSION

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We present a concept model on how fusion reaction takes place in solids at room temperature. The model allows explaining in a unitary manner some of the most important facts observed in cold fusion experiments. The model is based on solid-state physics considerations. We show that no "exotic" effects are needed for explaining the phenomenon.

First of all, we are able to explain how two deuterons can come so close that nuclear fusion appears at normal temperature. Even if it uses a very rough approximation, the model shows that a distance of several femtometers between the two particles is possible, in principle, to be obtained. We discuss the main mathematical obstacles that are putting us in the situation to be not able to derive the distance of approach in a more rigorous way. Moreover, there is a need of more experimental data to check if the value of the estimated distance is the correct one.

A very important characteristic of the model is that the host material heating may be due not only to nuclear processes but also to non-nuclear ones. This may explain why nuclear products are not seen every time, even if heating of the material is observed. This non-nuclear process is a consequence of the model, being another reaction branch, the first one being the nuclear fusion.

We underline and show, at the concept level, that nuclear phenomena in solid matter have to be different from those taking place in the same material but in a liquid or gaseous phase.

The model explains why deuterium is more effective in producing the nuclear fusion reaction and diffuses easier than light hydrogen.

The model also explains the following features of cold fusion reactions: a) how electrostatic barrier may be overcome; b) why fusion appears in the regions with higher hydrogen concentration; c) why the reaction rate depends on the square of the hydrogen concentration; d) why the reaction rate increases up to a certain temperature above which it decreases; e) why fusion reaction is observed mainly with deuterium; f) why X-rays with certain wavelengths, not encountered in any X-ray spectrum of the knowm elements, are observed experimentally; g) how positive feedback appears; h) the effect of reaction rate enhancement during energetic particle (photons, electrons, ions) bombardment of the Pd target; i) it is predicted that X-rays with specific energies may decrease the reaction rate, a feature that is not yet reported experimentally up to now, at least to our knowledge.

We do not have yet a model of the physical mechanism by which the nuclei of the host lattice are transmuted towards heavier elements. However, we present some speculations about how this phenomenon is possible.

Fragmentation of Thin Wires under High Voltage Pulses and Bipolar Fusion

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Abstract

In the proposed paper we will present an alternative explanation of the phenomenon of wire fragmentation under high voltage pulses based on classical electromagnetism. For this phenomenon they have been proposed several explanations see [1,2,3,4,5,6] that to our opinion are adequate

As it will be shown by the proposed analysis the high transient currents produced by these high voltage pulses can form transient steady waves on the wires, acting as transient antennas, the basic harmonic of which is creating excess bipolar Coulombian forces between its opposite pulsating parts.

We also explain how this phenomenon can be utilized as a primitive example of low energy-high power disruptive phenomena that can affect even nuclear matter. The produced fusion effects has already been experimentally realized by many researchers however due to lack of proper explanation of the origin of the high forces they could not be used for fusion applications of practical importance.

We strongly believe that the proper electromagnetic explanation of these phenomena due to high bipolar forces arising by the transient steady currents on the wire under extreme voltage pulses can lead to fine tuning of proper electromagnetic devices that could use this type of "bipolar fusion" in energy and thrust applications of major importance.

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The effects of nuclear reactions in solids on the phonon dispersion relation

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The phonon dispersion relation is one of the most important information to know the properties of solids, because it is greatly affected by lattice and electronic structure of solids [1,2]. For example, a lattice with only one atom in a primitive cell only has acoustic lattice vibration. However, a lattice with more than one atom in a primitive cell has acoustic and optical modes of vibration. Furthermore, interactions between impurity ions are also effective on the features of phonons. If nuclear reactions occur in solids, they will change the lattice and electronic structures and interactions between impurity ions and so on. Therefore, the changes of phonon dispersion relations will give us the evidences of nuclear reactions in solids.

In this study, we have shown theoretical predictions about the effects of nuclear reactions in solids on the phonon dispersion relations. At the beginning, we have tried to treat one-dimensional palladium deuteride and obtain possible changes of phonon dispersion relations due to same simple reactions. In this model, the palladium ions and deuterons are distributed alternatively along a line and harmonic interactions between neighboring ions are assumed. The discussions about this simple model can be applied to our previous work on the Raman observation of the palladium deuterides [3].

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SUPEREFFECTIVE NUCLEAR SYNTHESIS ON CONDENSED TARGET WITH THE PARTICIPATION OF MONOCHROMATIC BEAMS OF LIGHT OR MIDDLE ISOTOPES

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In ordered crystal lattice very strong influence of crystal axes and planes electrical field on motion and interaction of fast charged particles with crystal atoms and nuclei exists. In works [1,2] it was shown that in monocrystal targets like LiD possibility of fusion process with the participation of both target nuclei (e.g. D) and beam of fast nuclei (e.g. T), directed at *Lindhard* angle, increases by 10-100 times relative to the possibility of alternative process of deceleration on atomic electrons. Such changes are based on the usage of specific channeling physics regime of motion, so called "overbarrier motion". Unfortunately, at such regime the processes of spatial redistribution and dechanneling of accelerated ions take place.

Another mechanism of "accelerating synthesis" optimization is connected with the forced formation of the coherent correlated states of channeling particles including the action of longitudinal-nonuniform or non-stationary crystal channels [3]. The usage of the correlated states of channeling particles greatly changes as the character of their interaction with crystal planes and axes, as the angular diagram of a leaving particle beam in that case, when the longitudinal length of the channel does not exceed the size of the area of mutual coherency.

The additional method of radical optimization of fusion processes with the participation of monochromatic beams of middle mass isotopes is proposed. It is well known that the presence of the Coulomb barrier is the main obstacle to performing nuclear reactions of synthesis with low energy of interacting nuclei. In order to make such reaction possible, it is necessary to place interacting particles in the same spot simultaneously (within the range of atomic force action). In this case, the cross section of nuclear reaction $\sigma = \sigma_0 D(E)$ depends on the energy of reciprocal movement of nuclei and matches the "internal atomic cross section" $\sigma_0 = S(E)/E$, where *S(E)* is the nuclear astrophysical factor. The features of optimized nuclear fusion model, with the use of accelerated average-mass ions beams and condensed-surface targets, based on resonant tunneling effect were considered. Optimization process is based on the usage of conditions for the interaction of nuclear beam and target, for which "internal cross-section" σ_0 of fusion exceeds the cross-section of crystal low-level cell, and resonant tunneling effect provides the full transparency of reaction barrier. As it was shown the usage of particle beams with the optimal energy and small (but real) energy distribution, which corresponds to total transparency "window" of reaction barrier, leads to the possibility of positive nuclear fusion energy release on one atomic monolayer! Such effect can be regarded as nuclear super absorption of accelerated beam. The possibility of nuclear reactions $C^{12} + O^{16}$ and $C^{12} + O^{18}$ at such motion regime with positive energy release was examined.

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NUCLEAR TRANSMUTATION IN ELECTRICAL DISCHARGE SYSTEMS BY ULTRA-CLOSE RANGE CASIMIR EFFECT

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A series of recent lectures given by some of the UK's leading scientists have all mentioned the fact that around 75 per cent of equivalent mass of the universe is made up of "The energy of the vacuum field" or "Zero point energy" and dropping hints that it is worth investigating further just in case we can use it. It is well known that phenomena of electrical discharge always bring on transient energy concentration temporally and spatially[1,2]. Highly localized nuclear activation in electrochemical systems and other electrical discharge processes had been observed at many laboratories in world. Based on the theory of vortex dynamics, the strange phenomena of "cold fusion", such as the excess heat, anomalous nuclear transmutation and so forth, are considered to be interpreted by the torsion coherence with the zero-point energy induced by localized intense field emission of micro-protrusion of the cathode, and the dynamic Casimir effect of transient evolution of triple region of gas, liquid solution, and electrode protrusion. In fact this process induces a variety of high energy, deterministic nuclear fusion reactions between relatively large nuclei, "triggered" by low input energies, generally not considered possible in the conventional physics frame. A logical extrapolation of this discovery is that the strong force of the nucleus is in fact an ultra-close range Casimir effect[3]. Fusing ions capture electron to convert excess protons to neutrons is a common occurrence and a key to the production of stable isotopes without neutrons or radiation.

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On electrolysis-induced emission of charged nuclear projectiles

Ludwik Kowalski, William Beaty, Jeff Driscoll, Mike Horton and Pete Lohstreter

According to Richard Oriani, production of nuclear projectiles due to electrolysis, using his protocol (1), is highly reproducible. The Curie Project was organized to verify this claim. The electrolyte is a solution of Li2SO4 in light water. The cathode is nickel and the anode is platinum. Nuclear projectiles are detected with CR-39 chips (2,3,4,5) protected from the electrolyte by a thin Mylar film. The work is in progress. Preliminary results confirm emission of nuclear projectiles, similar to alpha particles. But the effect does not seem to be reproducible.

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MATERIAL DATABASE FOR ELECTROCHEMICAL LOADING EXPERIMENTS AT ENEA

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A large number of Palladium cathodes have been crafted, in many years, to perform chemical loading experiments. These cathodes underwent, very often, different production processes, characterization procedures and experimental conditions. The need to keep trace of all the steps of the "life" of a cathode was the starting point for the creation of a database. The information stored in this useful archive puts us in condition of easily compare different cathodes and try to correlate their experimental behavior with their history.

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Published by:

ENEA - Nucleo di Agenzia
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