JOURNAL OF NEW ENERGY

An International Journal of New Energy Systems Vol. 2, No. 2, 1997

Published by the
Fusion Information Center
P.O. Box 58639
Salt Lake City, Utah 84158-0639

A Quarterly Journal
Subscription: $150 for 4 issues
Single issues: $45

Summer 1997

ISSN 1086-8259

EDITORIAL COMMENTS

The *Journal of New Energy* is devoted to aid in solving the world's energy problems by providing rapid professional communications on new-energy topics. Our goal is to be one of the leading publications to inform scientists and engineers about the latest new-energy devices and systems that can reduce our reliance on scarce, expensive, and polluting fossil fuels.

The essence of new science is discovery. Major new discoveries are seldom the result of theoretical investigation of previous discoveries. Major new discoveries precede major new theories. To have a major new theory requires a sequence of **discovery; hypothesis and experiment to test hypothesis (repeated many times); the creation of a new scientific fact; and then a major theory.** The definition of a scientific fact is: **the close agreement of a series of observations of the same phenomena.**

Cold fusion was a major new scientific discovery. That anomalous amounts of excess heat can be produced in a properly conducted cold fusion experiment is now, by definition, a scientific fact. However, there are at least 26 theories of cold fusion. Perhaps one of them is correct. As of September 1997, there is no major new scientific theory of cold fusion.

True scientific researchers are not encumbered by previous knowledge that has been institutionalized as dogma. True scientists, however, must have a combination of healthy skepticism bolstered by an intense desire to explain new scientific anomalies. The contributors to this journal include such scientists. From such contributors this journal is pleased to present **another remarkable new discovery: torsion fields.**

In this issue (and planned for future issues) this journal will present experimental evidence for the existence of other fields in addition to electric, magnetic, and gravity. Peers (especially in the United States) to review papers on torsion fields are almost non-existent. Therefore, until such peers emerge, some of this new material may be published as "Editor's Choice." See the paper by Akimov and Shipov in this issue and marvel at fields that appear to travel faster than light!

Now that Low-Energy Nuclear Transmutation Kits are being sold, this editor is pleased to announce our plans to solicit and publish the latest information of experimental low-energy-produced nuclear transmutation. Don't miss an issue.

Respectfully, Hal Fox, Editor

Journal of New Energy

Volume 2, Number 2

COLD FUSION RESEARCH: MODELS AND POTENTIAL BENEFITS

James J. Hurtak [1], Patrick G. Bailey [2]

ABSTRACT

Observations have been made of deuteron-deuteron fusion at room temperature during low-voltage electrolytic infusion of deuterons into metallic titanium or palladium electrodes. Neutrons with an energy of approximately 2.45 MeV have been clearly detected with a sensitive neutron spectrometer at a rate of 2 x 10^{-3} n/s which cannot be accounted for by ambient neutron background variations. The reaction has been known to yield excess (or "latent") heat, where D + D yields ^{4}He + 23.8 MeV. This paper will examine the latest experimental results from several international researchers and summarize several new theories of nuclear model interactions that have been put forth to explain these intriguing results.

RESULTS

Cold fusion has been largely a study of results first and theories which then must follow. Since most results from solid fusion experiments do not agree with old and contemporary nuclear theories, new theories are being generated to account for these new data and results.

After the Pons and Fleischmann announcement, numerous institutions all over the world began their own experiments. As of 1996 there were over 100 independent research groups investigating the potential possibilities of this new energy anomaly worldwide. Not all experiments have been successful and as research has persisted several new theories have been explored based on the new data found from various substitutions from the original experimentation in an attempt to determine a clear theory as to the factors that are occurring within the electrolytic cell. One of the most important results is the discovery of neutron emissions in the form of bursts which have been observed by De Nino, Sanchez, and Gozzi (De Nino, 1989), (Sanchez, 1989), (Gozzi, 1992). Neutron spectra with a 2.45 MeV peak should be evidence of deuteron-deuteron (D + D) fusion. However, the detection of neutrons is complex and expensive, requiring a great deal of equipment and experimental expertise.

A University of Rome study showed that after imposing a constant current density of 200 mA/cm^2, the nuclear and thermal effect was first recorded after 150 hours! Then in a time interval of 22h5'54", the neutron recorder counted 80 single spikes! Before and after the event, the neutron counting rate was equal to the background level. During the entire experiment, at least 36 counts were concentrated in an unresolved group which would imply an emission of 7.2 x 10^5 neutrons in 4 minutes, or 3 x 10^3 n/s, while the electrode temperature increased to a value of 150°C (with an overall temperature change average of 100°C) (Gozzi *et al.*, 1990).

The University of Hokkaido in Japan, using a palladium rod of 99.9% purity and 0.3 cm in diameter, indicated the generation of neutrons. The experiment was conducted in a concrete room about 5 meters below the ground to shield it from background neutrons.

[1] AFFS Corporation, P.O. Box FE, Los Gatos, California 95031 < affs@affs.org >

[2] Inst. for New Energy, P.O. Box 201, Los Altos, California 94023 < pgb@padrak.com >

The Tata Institute of Fundamental Research in India recorded a temperature rise of 1 degree Celsius per minute, as well as neutrons and gamma rays, estimating about 2 in every 50,000 deuterium atoms were fusing.

In America, in addition to Brigham Young University and the National Cold Fusion Institute at the University of Utah, the University of California at Santa Barbara, Case Western Reserve University, University of Florida, University of Minnesota, the U.S. Naval Research Laboratory, Los Alamos Laboratory, and EPRI (connected with Stanford University, Stanford Research Institute International and Texas A & M) are among those who conducted their own experiments. John Bockis at Texas A & M's Department of Chemistry and the Cyclotron Center established over ten cells and reported the production of tritium from D_2O electrolysis at a palladium cathode, with the maximum tritium count observed in one cell as 4.9×10^6 disintegrations per minute per milliliter, showing 100 to 100,000 times more than that expected from the normal isotropic enrichment from electrolysis.

Even after the critics assured the press that "cold fusion" was only a delusion of a few scientists, SRI International was willing to fund $3-4 million U.S. dollars per year for Michael C.H. McKubre's laboratory research into cold fusion in Menlo Park, California (McKubre, 1994). The funds were granted from EPRI. Other researchers include Edmund Storms at Los Alamos National Laboratory, Robert Bush & Robert Eagleton at California State Polytechnic University, and Thomas Droege, at Fermi National Accelerator Laboratory (Batavia, Illinois).

Although the U.S. Government has not thoroughly supported many of these projects, recently the Ministry of International Trade and Industry (MITI) in Japan has committed over 20 million U.S. dollars to this research. Pons and Fleischmann left their positions at the University of Utah to live in France and be funded by IMRA Europe, which is the European branch of the Toyota Motor Company research institute.

The Japanese have more finely attuned the state of the art and have made the most impressive and consistent advances in cold fusion research of all countries. [However, of the 7 companies who are commercializing electro-nuclear energy systems, 6 are U.S. companies and 1 is Italian.] Their research interest was spawned by a successful experiment by Akito Takahashi (1992) at Osaka University who reported that he was able to successfully produce an average of 70% more heat than his device consumed in electric power by "cycling" the input power, alternately running the current at higher and lower levels for long periods of time. After Takahashi's experiments, Storms at Los Alamos reported that he was able to operate his device for just under 300 hours also with an output of excess heat. The best research still goes to the NTT (Nippon Telephone and Telegraph Corporation) experiments by Japan's Eiichi Yamaguchi.

Eiichi Yamaguchi, a physicist at NTT (Japan), made significant confirmations in his lab by designing his own experiment. Yamaguchi used palladium coated with gold on one side. The palladium is saturated with deuterium gas and placed into a vacuum chamber and the electric current is turned on. Within three hours, the palladium increases in temperature and is capable of generating 5 Watts of excess heat for 10 minutes, releasing a gas containing ^4He.

Bockris (Texas A&M) also claims that 2 to 200 times more atoms of ^4He are contained in the palladium rods than those in his "control" experiment. Researchers soon expect to be able to document for public inspection, energy increases from 30 to 70 percent in excess of electric power input. Researchers in India have already reported 70%, and Thermacore Inc., in the United States, claims that compared to 18 Watts of power in, they are producing 68 Watts out for an excess heat production equal to 50 Watts.

Excess tritium (T) was also detected, and this presence of nuclear by-products indicates that a nuclear reaction is taking place. Texas A & M's Department of Chemistry and the Cyclotron Center built and tested over ten cells and reported the production of tritium from heavy water (D_2O) electrolysis at a palladium (Pd) cathode, with the maximum tritium count observed in one cell as 4.9×10^6 disintegrations per minute per milliliter, showing 100 to 100,000 times more than that expected from the normal isotropic enrichment from electrolysis (Bockris, 1989a). Critics claim that if tritium is being produced at 1.008 MeV, then equally large quantities of neutrons must also be present. However, if the neutrons are not always inside the nuclear well, it is possible that the neutron is stripped away to form tritium with the other deuteron which would account for the large excess of the emission ratio of tritium over neutrons (t/n). In cold fusion electrochemical cells, tritium has been measured at levels of 10^{13} atoms per milliliter, yet actual t/n ratio of emission has been estimated to be about 10^8:1(Iyengar, 1989). These ratios indicate that the reaction:

$$D + D \rightarrow T + H$$

appears to be the dominant reaction taking place in cold fusion.

However, neutron and tritium emissions are not the most common factor of most cold fusion experiments. For the most part cold fusion reactions produce excess thermal energy, enough excess (or "latent") energy to heat the water surrounding the electrode. Heating the water is an inherent characteristic of the electrochemical fusion reaction. These reactions have produced sufficient heat to cause water to boil. If the fusion cell is pressurized, higher temperatures can be obtained, but only low-level heat can be produced since the metal lattice tends to give deuterium at higher temperatures (S. Pons and M. Fleischmann, 1989). Water temperatures in excess of 170°F. have also been observed (Haag, 1990).

The argument of the physics community is that the amount of heat does not correlate with the limited number of neutron emissions. ^4He has also be generated which can correspond to the level of heat produced. The reaction:

$$D + D \rightarrow {}^4He + \text{a beta, phonon or plasmon (at 24 MeV)}$$

has been proposed. But in many experiments far too little ^4He has been detected to prove that these reactions are occurring.

The opponents suggest that a chemical reaction of some type must be occurring. However, the results have shown excess heat anywhere from 10 W/cm^3 Pd to 100 W/cm^3 Pd (or about 1.0 keV/atom) has been reported in many different cells from various institutions.

Additional experiments and reports internationally also have shown Pd x-ray lines and clear evidence of nuclear transmutation events.

THE FACTORS

In a chemical reaction, only a few electron volts (eV) of energy are released per atom taking part in the reaction, and even fewer in a mechanical process. In a nuclear reaction, millions of electron Volts (MeV) can be released per atom. If all the atoms in an electrolytic cell were to react, the energy release would be on the order of a thousand electron Volts (keV)/atom.
There are several approaches to heavy water cold fusion development but the basic approach since 1989 has deviated only slightly from the original Pons and Fleischmann model using electrolysis of Lithium deuteroxide (LiOD) on palladium (Pd), where a palladium cathode is

immersed in an heavy water-based electrolytic solution of 0.1 molar LiOD in 99.5% D_2O + 0.5% H_2O. The LiOD is added to make the electrolyte conductive. The palladium *cathode* is surrounded by a bare platinum wire helical *anode*. A unique property of palladium is its ability to absorb large quantities of hydrogen (or deuterium) as the cathode in an electrolysis cell. [However, no known heavy water devices are a part of the commercialization of electro-nuclear energy systems. --Ed.]

The platinum wire anode is attached to a positive DC voltage while the palladium is charged negatively. Direct current is supplied at 3-25 Volts across each cell at currents of 10-500 mA. Specific correlations between fusion yield and voltage, current density, or surface characteristics of the metallic cathode have yet to be clearly established. The fusion reaction occurring produces excess thermal energy inside the palladium metal electrode, and raises the temperature of the water surrounding the electrode.

There are various approaches to loading the palladium, one of which incorporates the use of pulsed heating which has a clear effect on the loading speed. Many researchers consider pulsed current an important factor, along with temperature variations.

Very high pressure does not stimulate cold fusion phenomena. However, further research is examining the effects of magnetic and optical irradiation, ultrasonic waves (>10^9 Hz), and the use of pressure waves.

Also, certain foreign atoms may enhance the surface dynamics, such as vanadium, aluminum, and tin in titanium or the silver in palladium. Alloys may be more efficient than pure metals.

The cathode, Palladium, is a face-centered-cubic (fcc) crystal lattice with a side of about 3.89 Angstroms. If hydrogen is loaded into it, the crystal expands slightly to 4.03 Angstroms with a D-Pd ratio of 0.8. In the Pd-D lattice there are rows of deuterons along direction [110] and λ is [a/2 $\sqrt{2}$ n] for coherence, *a* being the lattice constant (Vaidya, 1993).

Palladium functions as an absorber of hydrogen or deuterium ions, as well as a resistance problem to monitor the loading ratio, and also a resistive heater to raise the temperature. After electrolysis in an electrolyte containing both H and D ions, the cold-rolled palladium cathode has been shown to produce macroscopic deformations on the surface, eventually leading to craters and in some instances exhibiting faceted crystals inside the craters (Silver, 1993).

THEORIES

In 1989, Pons and Fleischmann publicly announced their results, (and also the results of others) using the term "cold fusion," and since that time many theories have been put forth to account for some or all of their results. Some researchers continue to see their results as purely fusion based, others have come up with terms such as "new hydrogen energy," or "chemically assisted nuclear fusion" or "cold nuclear fission." The biggest conflict appears to be designing a theory in which the nuclear Coulomb barrier is overcome even at low temperatures.

In a deuterium molecule occupying octahedral sites, where the equilibrium separation between D-D is 0.74 - 0.94 Angstroms (Å), the fusion rate is exceedingly slow, about 10^{-74} per deuterium molecule per second. One of the important factors appears to be the Pd which when loaded appears to bring deuterons much closer together than they could otherwise get at ambient temperature. Although the average separation of deuterons is approximately 1.4 Å in heavily loaded palladium, the deuterons can be in equilibrium at a separation as close as 0.94 Å.

Here the interstitial lattice sites may be considered shallow potential wells allowing for high deuteron mobility and, possibly, an enhanced probability of fusion through the repulsive, proton Coulomb barrier. In actuality, the neutrons and protons are only weakly bound in deuterons and may be outside the D nuclear well a large portion of the time.

The Pons-Fleischmann Process

It was originally thought that, as the voltage is applied across the electrodes through electrolysis, the heavy water (D_2O) is split into oxygen and deuterium (Pons and Fleischmann, 1989). The deuterium atoms are absorbed into the palladium at octahedral sites on the crystal lattice while oxygen accumulates at the platinum anode. The deuterium density is greater than that of liquid hydrogen.

The fusion reaction is catalyzed by the deposition of D^+ and metal ions from the electrolyte at (and into) the negative electrode. The deuterium atom ionizes with its electrons entering the band structure of the palladium. After various times of charging (or "aging"), the palladium rod is supersaturated with deuterons, and it has a crystal lattice structure like NaCl (King, 1989). All lattice sites are occupied, and the excess free deuterons form a "protonic fluid" which can aid electrical conduction. Thus, although metals such as palladium and titanium are used to support the fusion reaction, they are not consumed in the process of solid-state fusion. Instead the fuel consumed is the deuterium in the heavy water.

The Surface Model and Three-body Collisions

John Bockris at Texas A & M also describes the "surface model" which does not consider that the fusion occurs within the electrode, but suggests that the surface of the electrode might be the site of the reaction. He suggests that fusion reactions occur at specific points, or protuberance on the surface of the electrode (Bockris, 1989b). Here fusion occurs on the lattice, not within the lattice, whereby the lattice is a reservoir of deuterium providing enough raw material for the dynamic process that takes place even after the electrolysis is stopped or D_2O and LiOD is replaced by H_2O and LiOH (Glueck, 1993).

Jacques DuFour of Shell Research S.A. in France believes that when a transient electrical field is created by sparking through the gas between two dissymmetrical electrodes, the surface layer of hydrogen isotopes builds a three-body collision of two hydrogen isotopes and one electron (DuFour, 1993). The accumulation of these species in a surface layer of the electrode metal can be explained by the known properties of sparks and of hydrogen isotopes in metal, implicating the weak electronuclear force that yields products completely different from those of hot fusion, whereby a deuteron is a two-nucleon system containing weak interactions.

According to DuFour there is a whole class of nuclear fusion reactions at room temperatures, involving "three-body collisions" of two hydrogen isotopes and a neutrino, which through an indirect transition (virtual neutron states), have reactions favored by the high electron and proton concentrations existing in the metal and the high transient electrical field created by the sparks.

Very high thermal energy prevents the Coulomb forces from deviating their trajectories under conditions of hot fusion, but in metal there is a high concentration of low-thermal-energy protons and electrons at a mean distance of about 2 Å and when exposed to a transient electrical field the probability of the three-body collision increases. DuFour has estimated this collision at 10^{-12} s and 10^{-14} s, which is characteristic to the weak nuclear force.

A controversy has arisen over the need for refined palladium that is relatively free of microscopic cracks in order for the "cold fusion" process to succeed. Several researchers claim that if the electrode has too many cracks it will fail to produce the excess heat and a purity of 99.9% is required. Contrary to this belief, Rainer Kühne in Germany postulates that it is the cracks within the electrode (99.8% purity) that are the trigger for cold fusion (Kühne, 1994).

The crack hypothesis claims that the absorption of hydrogen gives rise to deformations and expansion of the metal lattice and that the formation of anions (metal ions) which allow for crack formations near the surface gives rise to deuterium absorption, whereby kilo-electron-Volt deuterons rapidly lose energy by collisions allowing areas of high temperature to arise. Kühne claims that at such locations deuteride bubbles collide, giving rise to electric fields and to kilo-electron-Volt deuterons in an ongoing process during the charging of the electrolytic cell.

The Two-Step Mechanism Involving Electron Capture by a Deuteron or Lithium Atom

This model represents a coherent and semi-coherent neutron transfer with increasing phonon coupling. It appears that on the surface of the Pd the D^+ can diffuse and combine with ingoing electrons where $2D^+ + 2e-$ yields D_2 or the D ions can also stay on the surface and be independent of the electrons. Another theory proposed by J.C. Jackson and Budelov is that the neutron could be captured by the Pd metal nuclei and used to produce a different isotope of palladium and a gamma photon which could cause a photodistintegration of the deuteron and could liberate a neutron. The byproducts would then be heat and electrons, explaining the low neutron production rate compared to the high excess heat output (Hagelstein, 1990).

Transmission Resonance

Dr. R.T. Bush of California State Polytechnic University has suggested that when a palladium lattice is fully occupied by deuterons, conditions are favorable to support laser-like actions where the deuteron-loaded lattice supports a type of resonating phenomena in which the probability of a traveling or "hopping" wave-like deuteron fusing with a target deuteron is increased significantly.

This may also be caused by the possibility of plasma oscillations of the D-shell. The theory that deuterons (protons) exist in deep energy wells may not be valid because the protons appear to be mobile in a similar state as classical oscillators. Bush's theoretical model accounts for the heavy water heat effect and light excess heat effect from cold fusion. It provides a unique and highly novel mechanism to sufficiently enhance tunneling through the Coulomb barrier, as well as incorporating the role of lithium in electrolytic experiments.

The transmission resonance model begins with the hypothesis:

$$D + D \text{ yields} \rightarrow {}^{4}He \text{ (23.8 mev)}$$

occurs for deuteron lattice configurations with nearest neighbors on either side to produce a "sideways charge polarization" with protons directly opposite neutrons. Vibration of the lattice is required for the oscillatory collisions of the nearest-neighbor deuterons to produce the tunneling. Tritium and neutrons result from the oscillatory collision of two nearest-neighbor deuterons isolated from their neighbors and thus favoring Bush (1994):

$$D + D \rightarrow T + p \text{ (4.03 mev)}$$

The Collapse Ground State

If one could increase ω_{min} of the zero point field associated with the establishment of λ_{max} this could cause the electron to spiral inward to increase its angular velocity where $\omega'_o = \omega_{min}$, where ω is the frequency of absorbed radiation and ω'_o is the electron angular velocity. It is believed that alkali atoms, the Li and D, or a mixture, may serve as crucial ingredients in the Casimir reflecting planes, whereby the Li-plane Casimir reflector separation corresponds directly to the Pd lattice spacing. The Casimir separation for the D-planes is twice as great (Bush, 1994).

In some experiments light water or ordinary water has been used successfully to reproduce results similar to the Pons-Fleischmann model. According to Dr. Randall Mills of Hydrocatalysis Power Corporation (Lancaster, PA), we may be viewing a catalysis process whereby the H electron is induced to undergo a transition to a lower electronic energy level than the "ground state," as defined by the usual quantum-mechanical model of the atom. Thus, stored energy in the atom is catalytically released.

It may be that the barrier to the access of the D in relationship to the tetrahedral sites is nothing but the zero-point energy of the harmonic oscillator in the *n*-direction.

The Tunneling Model

Nuclear interactions can be coherent when the difference in the phases of the wave functions of the compound lattice nuclear states formed by overlap between the itinerant deuteron (neutron) and the lattice deuterons (nuclei) is an integral multiple of 2π (Vaidya,1993).

Tunneling has been considered a quantum mechanical phenomenon, where a particle whose energy is less than the potential energy of a barrier can overcome the barrier of electrical repulsion. Calculations by Rabinowitz and scientists at EPRI have shown that it is possible for the effective mass of the deuterium nuclei in a solid to be sufficiently less than the mass of deuterons in free space (Rabinowitz, 1990). This can increase the tunneling coefficient by many orders of magnitude.

By replacing the electron in a hydrogen molecular ion with a more massive charged particle, the fusion rate is greatly increased. Mario Rabinowitz of EPRI likens tunneling to a classical high jumper where an extended body can clear a barrier even when its energy is less than the potential energy of the barrier, if it can communicate with and be aided by the interaction on the other side of the barrier.

Tunneling would strongly favor reactions with reduced masses such as:

$$D + p \rightarrow {}^3He + gamma.$$

According to Charles Horowitz, the electrons in metallic hydrogen can be modeled as a Fermi gas of electrons and a crystal of nuclei. Palladium is a transition metal that in its *alpha* phase has a face-centered-cubic (fcc) lattice structure and a lattice constant of 3.89 Å and a nearest-neighbor distance of 2.75 Å fcc lattices in the orthohedral sites. In the highest packing fraction of 1.0 - 1.5 Å. Under normal conditions, in D_2 gas or liquid states, the separation of the deuterium nuclei is 0.74 Å. However, for muon-catalyzed fusion to occur this must be at least 0.035 Å.

A zero-point energy of approximately 0.06 eV can be assumed which leads to the first-excited state above the potential minimum near 0.1 eV. The question is: Can 0.1 - 1.0 eV deuterons penetrate the Coulomb barrier? We know that the electron screening length is shorter than the interparticle spacing reducing the width of the Coulomb barrier. However, the deuterons must be within the scale of the fusion barrier (r_0) of approximately 0.37 - 0.125 Å in order for the cold fusion rate to be near the claimed reaching states of 10^{23} s^{-1} $deuteron^{-1}$ as seen by Jones *et al.* (Jones, 1989).

According to Adam Burrows of the University of Arizona, this would first require that the deuterons (positive) and the deuteride (hybrid) exist not as atoms or molecules, but as screened positive charges with screening clouds having the required length (Burrows, 1989). However, this would still not be sufficient since cold fusion reaction rates also require the increasing of the tunneling integral by unity to increase the fusion rate. Moreover, a vacuum zero-point energy stimulated by a resonance effect that matches the palladium cathodes atomic mass may be required to create the proper tunneling potential.

A further expansion of tunneling comes when the centrifugal barrier is combined with the Coulomb barrier. Here penetration can be increased due to the resonance level between the Coulomb barrier and the centrifugal barrier.

The E-Cell Theory

According to the theory put forth by Gennady Fedorovich *et al.* of the Russian Academy of Sciences, the E-cell is a radiation defect of a crystalline lattice of a hydride which forms as a result of the capture of a thermal neutron by the nucleus of an atom where, for example:

$$^{6}Li + n \rightarrow {}^{4}He + T + 4.785 \text{ mev}$$

Here the reaction products leave the cell in 10^{-17} s which is shorter than the electron system (10^{15} s). Hydrogen nuclei and the average density of free electrons in the central region of the E-cell exceeds 10^{24} cm^{-3} which results in a greater suppression of the Coulomb barrier. According to Fedorovich's calculation, to confine the surplus electrons in the E-cell, the pressure in the LiH crystal must be >10 to 20 Mbar, where the motion of the hydrogen nuclei form a collective movement and at some phases of the movement, the potential energy is transformed into kinetic energy, the nuclei approaching a distance of <0.1 Å (Fedorovich, 1993).

Jahn-Teller Symmetry Breaking and Hydrogen Energy in Gamma-PdD

Keith Johnson from MIT has proposed a chemical process which corresponds to an "internal phase change of the deuterium within the gamma-PdD lattice." He believes that the energy released is caused by the internal cyclic gamma-phase change of atomic deuterium to dideuterium. The heat produced is "latent," in that it is produced by repeated formation of the "interstitial sublattice" of the D-D bonds between the tetrahedral interstices in gamma-Pd-D. According to Johnson, as atomic deuterium diffuses into Pd and dideuterium diffuses out causing 9.4 eV per Pd atoms for 6.8 x 10^{22} Pd atoms/cm^3 (Johnson, 1994).

Due to the high symmetry coordination of a Pd atom by D atoms in four of the eight surrounding fcc-palladium tetrahedral interstitial sites, the Jahn-Teller effect is unstable leading to a central energy minimum of distorted tetrahedral symmetry and a planar "broken-symmetry" energy minimum 9.4 eV below the high symmetry at a shortened distance of 0.76 Å (almost equal to the bond distance of a free hydrogen molecule). The cycle time for recombination (4D to $2D_2$) is difficult to calculate, but it would be somewhere between 1 and 100 minutes at 9.4 eV per Pd atom per unit time. This process according to Johnson could generate heat at a rate of 17 to 1700 Watts/cm^3 Pd.

New Particle: The Iton Particle and Nattoh Model

J.F. Yang from Hunan Normal University suggested since 1989 the possibility that a new neutral elementary particle may be forming, where the deuteron captures an electron and is transformed into a dineutron $^{2}_{0}N$; the deuteron-dineutron reaction would then account for the cold fusion. The Nattoh model proposes a reaction that involves plural hydrogen atoms and electrons where:

$$2D + 2e + D \rightarrow {}^{4}N + I_2 + D$$

where ^{4}N is a quad-neutron and I_2 is a double iton. Matsumoto (1993) has observed ring spots caused by gravity decay of single and dineutrons upon copper plates after the cold fusion reaction. The double iton could explain warming or "Heat after Death" phenomena that occurs for up to three hours afterwards and is described by Fleischmann and Pons.

Given the D-D fusion model, further contention arises over the required kinetic energy required for a deuteron to overcome the Coulomb barrier. A deuteron in such a crystal is subject to forces from the crystal lattice, as well as the Coulomb force from another deuteron. For known D-D fusion, the deuteron must acquire more than 4×10^{5} eV of kinetic energy from the electrical field. Cold fusion, low-voltage electrolytic experiments uses only 10 V. The probability of a deuteron passing through the barrier is 10^{74} per second at normal room temperature, and in cold fusion experiments it is recorded to be 10^{20} per second.

Some research has suggested that hydrogen ignition is occurring at the air-water interface. From preliminary results obtained by Matsumoto and Hokkaido University using the Nattoh model, they predict that cold fusion can occur using ordinary water. The model is based on the hypothesis that hydrogen clusters are trapped in tiny cavities such as cracks and compress themselves to a induced hydrogen-catalyzed fusion reaction. Here cold fusion occurs when the hydrogen pressure exceeds a critical value under electrical current flow.

Matsumoto claims that a metal such as nickel which has low hydrogen permeability can be used whereby hydrogen clusters on the surface (Matsumoto, 1993).

RECENTLY PUBLISHED RESULTS

A private meeting entitled "Low Energy Nuclear Reactions Conference" was held in College Station, Texas, on June 19, 1995, to review the latest available results of "cold fusion" and "transmutation" experiments. The meeting was organized by J.O'M. Bockris and G.H. Lin and was held in a conference room at Texas A&M University. All of the papers from that conference have been publicly published in the *Journal of New Energy* (vol 1, no 1, eds. Bockris and Lin, Jan. 1996.) In the order listed below, eight papers were presented on "Basic Experimental Studies", four on "Theoretical Models", and five on "Innovative Approaches".

Each experimental paper presents positive and repeatable results of cold fusion and/or an atomic transmutation of elements (listed in the order as they are in the Proceedings):

EPRI: Low energy proton and deuterium reactions seen by Wolf in 1992 to produce Silver, Rhodium, and Ruthenium with excess neutrons and mild radioactivity. (T. Passell, 1995.)

Hakodate Nat. College of Tech, Japan: Production of iron isotopes with excess heat from gold and lead electrodes in electrolytic solutions. (T. Ohmori and M. Enyo, 1996.)

Scientific Industrial Assn., Russia: Glow discharge experiments with very pure Pd electrodes produce excess heat 2x-3x (2-to-3 times "over-unity") and several new elements. (A. Karabut, Y. Kucherov, I. Savvatimova, 1996.)

Portland State University: Excess heat and unexpected elements produced by electrolysis of Pd in several experiments. (S. Miguet and J. Dash, 1995.)

CalPoly University: Strontium produced from rubidium with excess heat in light water electrolysis with nickel electrodes. (R. Bush and ENECO, 1993.)

Hokkaido Univ., Japan: Excess heat 2x-to-4x and several nuclear products found in light and heavy water electrolysis cells using Pd and Ni electrodes. (R. Notoya.)

Ukrainian International Academy of Original Ideas: Various electrolysis results, including zinc turned into copper; and copper implanted into steel, with weight loss. (G. Rabzi, 1996.)

Ukrainian International Academy of Original Ideas: Formation of new elements with atomic numbers 82 through 40 via electrolysis with lead and zinc. (A. Fabrikant and M. Meyerovich, 1996.)

Purdue University: Optical Theorem explains low-energy nuclear fusion reactions and unstable product formations. (Y. Kim, 1996.)

CalPoly University: Electron Catalyzed Fusion Model fits EPRI/SRI cold fusion data and other data from Japan. (R. Bush and ENECO, 1996.)

Clustron Sciences Corp.: Nucleon Cluster Model provides explanations for cold fusion experiments and also for radioactive waste cleanup. (R. Brightsen, 1996.)

Clustron Sciences Corp.: Nucleon Cluster Model compares exactly with the Periodic Table of the Elements (discovered in 1869.) (R. Brightsen, 1996.)

Hokkaido Univ. & Hakodate Nat. College of Tech., Japan: Excess heat observed in 12 of 80 cases using powdered oxides and Pt in hot D_2 gas. (T. Mizuno, *et. al.*, and M. Enyo, 1996.)

Mt. States Mine and Smelter: Creation of helium and lithium from nitrogen gas using electromagnetic fields. (R. Kovac, 1996.)

Wireless Engineering: Creation of fluorine from water using shaped electromagnetic fields, duplicating some of the 1927 experiments of Walter Russell. (T. Grotz, 1996)

Los Alamos Nat. Laboratory: Creation of tritium from small palladium wires and voltages. (T. Claytor, D. Jackson, and D. Tuggle, 1996.)

Burns Developments, Ltd.: Experimental evidence for the "Alpha-Extended Model of the Atom." Demonstrated removal of radioactive thorium and creation of new and lighter elements in 15 tests igniting specific mixtures of elements. (R. Monti, 1996.)

FUTURE BENEFITS OF COLD FUSION

At the *Power-Gen '95 Americas* trade show in Anaheim, California, on December 4 & 5, 1995, Clean Energy Technologies, Inc. (CETI) of Dallas, Texas demonstrated a 1-kw cold fusion reactor. During the demonstration, between 0.1 and 1.5 Watts of electricity was input, and 450 to 1,300 Watts of heat was output. This was an increase from the ratio of 1:18x that had previously been demonstrated only a short time earlier in October 1995 at the International Conference on Cold Fusion (Rothwell, 1996).

According to Keith Johnson, if some of these theories are correct and 1 cm^3 of Pd is capable of yielding upwards of 1.7 kW of energy, this would eventually create system of 22 kW or 30 HP in automobiles with the possibility of "water engines" electrochemically generating both heat and hydrogen for a fuel cell.

The world's oceans contain a large amount of readily extractable heavy water, sufficient to meet the global energy needs for hundreds and perhaps thousands, of years. Heavy water production facilities will be needed. About one gallon out of every 7,000 gallons of ordinary water is heavy water (deuterium oxide or D_2O). The energy equivalent of a gallon of heavy water is about equal to 300,000 gallons of fuel oil. The cost of production of one gallon of heavy water is estimated at less than $1,000 or less than one cent per gallon of oil (energy equivalent).

A target range of 400% to 1000% excess energy generation for a given cathode design should be a commercial target for the system. Currently, the thermal energy output of electrochemical fusion reactors is being achieved with excess of electrical energy input by a factor varying from 25% to 600%. Fleischmann and Pons reported briefly achieving a factor of 100-fold thermal energy excess over electrical energy input and also have achieved boiling water at 100°C (Pons and Fleischmann, 1990).

Although energy generated has been in the 10 to 100 W/cm^3 range, for commercial products such as heaters up to 100 W/cm^3 of active deuterium-absorbing metal electrode materials would be needed that would allow for rapid response and short heating times.

In terms of domestic heaters where an electric or natural gas water heater can cost on an average $250-$400 U.S. dollars per year, after installation costs and capital expenditures which would hopefully be achieved at current heater prices, the average cost of heating a 5.50 kW fusion-based water heater could be as low as $50.00 per year (Haag, 1990). In addition, the low neutron radiation is highly desirable because there is only a limited amount of harmful radioactivity that could be easily shielded even for home use.

Heating tap water from 40°F to a temperature of 158°F requires an energy input of 0.26 kWh per gallon of water. The average consumption for a family of four is 80 gallons per day, requiring 20.8 kWh of energy. The height of standard residential water heaters is 152 cm, a deuterium storing metal rod electrode having this height and a diameter of 1.3 cm with a heat generation rate of 50 W/cm^3 of electrode, a corresponding energy output of 0.050 kWh cm^3 could be achieved with a volume of 200 cm^3 of electrode material.

Over $8 billion per year is spent on fossil fuels for heating water in the United States. This represents 4% of our total energy needs. The nuclear fusion based-water heater could save up to 90% of this cost for consumers per year.

The systems where industrials would be positively effected are: (1) Water Heating; (2) Steam generation for sterilization; (3) Water distillation; (4) Air conditioning; (5) cooking; (6) heating for greenhouses; (7) heaters for chemical processing plants; (8) heaters for various transportation vehicles (trains, planes, buses, trucks); (9) heaters for snow, ice removal; (10) heaters for swimming pools and hot tubs.

WEB SITES AND HOME PAGES

Several organizations are actively pursuing licensed commercial applications for their proven "cold fusion" technologies. Further information about these applications can be found on the Institute for New Energy web site at: www.padrak.com/ine/ .

CONCLUSIONS

The challenge before us is to move forward with the expansion of worldwide teamwork, the study of Li and Ni, reverse profiles for low nuclear concentrations, and to make a closer study of several elements such as Al, Bi, Ca, Dy, Gd and Sm that are considered the reaction products of requisite existence for Cold Fusion activity.

Many of these theories although different are similar—suggesting that there may be a unifying mechanism behind cold fusion phenomenon, such as zero-point energy fluctuations. Clearly the challenge beckons our full attention.

REFERENCES

John Bockris, 1989a. "A Review of the Investigation of the Fleischmann-Pons Phenomena." Texas A& M University, *Fusion Technol.*, vol 18, Aug. 1990, p 20.

J. Bockris, N. Packham, K.L. Wold, J.C. Wass and R.C. Kainthia, 1989b. "Production of Tritium from D_20 Electrolysis at a Rd Cathode," *J. Electroanal. Chem.*, vol 270.

J. Bockris, and G.H. Lin, 1996. "Proceedings of the Low Energy Nuclear Reactions Conference," *J. New Energy*, vol. 1 no. 1; Fusion Information Center, P.O. Box 58639, Salt Lake City, UT 84158-0638. www.padrak.com/ine/.

Adam Burrows, 1989. "Enhancement of Cold Fusion in Metal 'Hydrides' by screening of proton and deuteron charges," *Physical Review B*, vol 40, no 5, 1989.

Robert T. Bush, 1994 "A Unifying Model for Cold Fusion," *Trans. Fusion Technol.*, vol. 26, pp 431-440, Dec. 1994.

A. DeNino et. al., 1989. "Evidence of Emission of Neutrons from a Titanium-D System," *Europhysics Lett.*, vol. 9., p. 221.

Jacques DuFour, 1993. "Cold Future by Sparking in Hydrogen Isotopes," *Fusion Technology*, vol. 24., Sep. 1993, pp 205-222.

Gennady V. Fedorovich, 1993. "A Possible Way to Nuclear Fusion in Solids," *Fusion Technology*, vol 24, Nov. 1993, pp 288-292.

Peter Glück, 1993. "The SURFDYN Concept: An attempt to Solve the Puzzles of Cold Fusion," *Fusion Technology*, vol 24, Aug. 1993, pp 122-126.

D. Gozzi *et al.*, 1990. "Evidences for Associated Heat Generation and Nuclear Products Release in Palladium Heavy-Water Electrolysis," *Il Nuovo Cimento*, vol 103 A, no 1, Jan. 1990, pp 143-151.

D. Gozzi *et. al.*, 1990, "Neutron and Tritium Evidence in the Electrolytic Reaction of Deuterium on Palladium Electrodes," *Fusion Technology*, vol 21, p 60 .

Arthur Haag, 1990. Personal discussions for Electrofusion, Inc. Houston, in Honolulu, HI, June 1990.

Peter L. Hagelstein, 1990. "Coherent Fusion Reaction Mechanism," *Proc. 1st Annual Conf. on Cold Fusion*, Salt Lake City, Utah, Mar. 28-31, 1990, p 99.

P.K. Iyengar, 1989. "Cold Fusion Results in BARC Experiments," *5th Intl. Conf. Emer. Nuclear Energy Systems,* Karlsruhe, Germany, 1989.

Keith Johnson, 1994. "Jahn-Teller Symmetry Breaking and Hydrogen Energy in Gamma-PdD "Cold Fusion" as Storage of the 'Latent Heat' of Water," *Trans. Fusion Technol.*, vol 26, Dec. 1994, pp 427-430.

S.E. Jones, E.P. Palmer et al., 1989. "Observation of cold nuclear fusion in condensed matter," in *Nature*, vol 338, 27 Apr. 1989, pp 737-740.

Moray King, 1989. Tapping the Zero-Point Energy. Paraclete Publishing Provo, Utah, 1989, p 145.

Reiner Kühne, 1994. "The Possible Hot Nature of Cold Fusion," *Fusion Technology*, vol 25, Mar. 1994.

Takaaki Matsumoto,1993. "Observations of Meshlike Traces of Nuclear Emulsions During Cold Fusion," *Fusion Technol.*, vol, 23, Jan. 1993.

Michael C.H. McKubre, et al., 1994. "An Overview of Excess Heat Production in the Deuterated Palladium System," *1994 Intersoc. Energy Conver. Engineering Conf.*, Aug. 1994, pp 1478-1483.

E. Palibrods and P. Glück, "Cold Nuclear Fusion in Tin Foils of Pd" *J. Radioanal. Nucl. Chem. Letter*, vol 154, 1991.

T. Passell, "Overview of EPRI program in deuterided metals," *J. New Energy*, vol 1, no 1, pp 9-14.

S. Pons and M. Fleischmann, 1989. "Electrochemically Induced Nuclear Fusion of Deuterium," *J. Electroanal. Chem.*, vol 261, p 301, 1989.

S. Pons and M. Fleischmann, 1990. "Our Calorimetric Measurements of the Pd/S Systems," 1st Conf. on Cold Fusion, Salt Lake City, Utah, 27 Mar. 1990.

Mario Rabinowitz, 1990. *Physics Letters*, vol 4, no 4 1990, pp 233-246;

Mario Rabinowitz, 1990. "Cold Fusion: Myth Verses Reality," *IEEE Power Engr. Review*, Jan. 1990, pp 16-17.

Jed Rothwell, 1996. "One Kilowatt Cold Fusion Reactor Demonstrated," *Infinite Energy: Cold Fusion and New Energy Technology*, Jan. 1996.

C. Sanchez, et. al., 1989. "Nuclear Products Detection During Electrolysis of Heavy Water with Ti and Pt Electrodes," *Solid State Commun.*, vol 71, p 1039, 1989.

David Silver et. al., 1993. "Surface Topology of a Palladium Cathode After Electrolysis in Heavy Water," *Fusion Technology*, vol 24, Dec. 1993.

E. Storms, 1991. "Review of Experimental Observations About the Cold Fusion Effect," *Fusion Technol.*, vol 20.

S.N. Vaidya, 1993. "Comments on the Model for Coherent Deuteron-Deuteron Fusion in Crystalline Pd-D Lattice," *Fusion Technol.*, vol. 24, Aug 1993.

[Editor's Note: For an alternative theory on cold fusion, read Shoulders & Shoulders, "Observations on the Role of Charge Clusters Reactions," *J. New Energy*, vol 1, no 3, Fall 1996; and the following paper by Moray King. –Ed.]

CHARGE CLUSTERS: THE BASIS OF ZERO-POINT ENERGY INVENTIONS

Moray B. King [1]

ABSTRACT

Many "free energy" inventions utilize (sometimes unwittingly) the phenomena of charge clusters, which may provide the coupling to the zero-point energy (ZPE) for their source of power. Shoulders demonstrates how to produce these micron sized plasmoids, called electrum valium (EVs), and his measurements show they contain a net charge on the order of 100 billion electrons. Recent investigations of the EV suggest its anomalous stability is due to a thin, helical, vortex ring filament possessing an extraordinary poloidal rotational velocity. Such a vortex ring has characteristics similar to the well studied filamentation instability, an intensely tightening, force-free vortex that occurs in non-neutral plasmas; for an EV the filament closes upon itself. The vortex ring can be launched when ions in a highly polarized plasma (or dielectric during breakdown) rush toward a point cathode (or dendrite in a fracturing crystal) whose tip explodes in response to a sharp, electrostatic pulse. EV production is likely occurring in fracto-emission, sonoluminescence and in most electrical discharges. If so, it can be the foundation for a unifying hypothesis to explain the energy source behind a wide variety of seemingly diverse inventions including Moray's and Correa's plasma tubes, Grigg's hydrosonic pump, Sweet's conditioned barium ferrite, Brown's electrogravitic capacitors, Gray's motor, Hyde's generator, and even cold fusion. The inventions which utilize fracto-emission as their basis tend to retain the EV plasmoids, and their simple construction offers the opportunity for widespread replication.

INTRODUCTION

Could there be inventions that tap energy directly from empty space? That depends on the nature of the fabric of space. Today most scientists believe that empty space is simply a void. Across history mankind believed just the opposite. For example, ancient Eastern philosophies viewed space as filled with an all-pervading energy called "prana." Since the inception of Western science to the turn of the 20th century, space was thought to be filled with a hypothetical substance called the aether (æther), which would be the medium to support the propagation of light waves. When modeled as a material substance, the aether seemed contradictory. It had to be tenuous to allow matter to pass through it without notice, yet extremely rigid to manifest the high velocity of light. The null result of the Michelson-Morley experiment to detect the aether wind perhaps came as a relief to the scientific community because they could simply accept the postulates of relativity, which yield the principle of Lorentz invariance, without dealing with a cumbersome theoretical artifact that would tend to deny it.

The principle of Lorentz invariance means the state of a physical system (i.e., laws of physics) are the same for all bodies (or observer frames of reference) when they are moving at any constant velocity in free space (an inertial frame). A simplistic, material model of the aether would immediately violate the principle since different observers would experience an aether wind as they move relative to it. Attempts to contrive hydrodynamic models where a material aether is dragged or flows beget complexity as the models are adjusted to recover Lorentz invariance, and in addition, the aetheric substance must be both tenuous to matter yet rigid for light. The principle of relativity

[1] P.O. Box 859, Provo, UT 84603

with Lorentz invariance is so fundamental to physics, that the scientific community really can't be blamed for using Occam's razor to excise the belief in a material aether, for a simple void model yields the principle immediately.

ZERO-POINT ENERGY

However, the void model cannot explain the nature of light, which was why the aether was invented in the first place. Nor can classical physics explain the spectrum of blackbody radiation, or even why electron atomic orbits don't collapse. The resolution occurred in the 1930's with the theory of quantum mechanics, a mathematical formalism that modeled atomic processes remarkably well. The equations contained a term that represented an underlying, energetic jitter inherent in all processes in nature. The jitter was called the "zero-point fluctuations" (ZPF) or "zero-point energy" (ZPE) since the energy is not thermal and is present at absolute zero degrees Kelvin. Dirac [1] proposed that the source of the jitter was from the fabric of space itself, and it could manifest short-lived pairs of elementary particles, each with their corresponding antiparticle. These were called "virtual" due to their short life times. The discovery of anti-matter and particle pair production in accelerator experiments popularized Dirac's view of space. In the 1940's the theory of quantum electrodynamics [2] was established that heavily relied on the action of the virtual particles to explain atomic interactions with electromagnetic fields. The theory was so successful and accurate, it became the ansatz (patten) for later theories to model the weak and strong nuclear interactions. In face of such success, do virtual particles really come into physical existence, or are they just an imaginary, theoretical construct?

Rather than have the virtual activity as a theoretical artifact, the theory of stochastic electrodynamics [3] has the zero-point energy at the foundation of all processes in physics, and it shows how quantum behavior arises from it such as blackbody radiation [4] and atomic stability [5]. Recent work has shown how the ZPE may also be at the foundation of macroscopic phenomena such as gravity [6] and inertia [7]. From this perspective, the aether has effectively re-entered physics, not as a material substance, but rather as comprised of highly concentrated fluctuations of electromagnetic field energy.

Stochastic electrodynamics postulates that the ZPE spectral energy density, the function that describes how much energy is stored in space at each frequency, must be Lorentz invariant. There is only one functional form that fulfills this postulate, and that is the energy density must be proportional to the frequency cubed [3]. The function's scaling constant is related to Planck's constant which completely specifies the description of the ZPE spectrum. The spectrum yields accurate results when used in calculations, but there is one philosophical problem: the energy density at every point in space appears to be infinite, since the spectral energy density keeps rising with frequency. Quantum electrodynamics suffers the same problem with its virtual particles, and uses a scheme of "renormalization" to subtract off infinities to leave a finite residue when making calculations. In a practical interaction with matter, the very high ZPE frequencies would be too fast to be absorbed. Nonetheless, the question remains: from where does the zero-point energy come, and how can it appear infinite at every point in space? Likewise, where do these virtual particles come from that pop in and out of space?

Wheeler [8] answers these questions in his "already unified" theory that combines stochastic electrodynamics with general relativity called "geometrodynamics." General relativity shows that when mass or energy density become large, the fabric of space bends into a fourth dimension, and with sufficient density pinches into a hyperspatial form called a "wormhole." The wormhole channels the zero-point energy in the form of electric flux (high density field lines) in a direction orthogonal to our three dimensional space. Flux appears to enter our space through "mini white holes" and leave through "mini black holes." The size of these holes are on the order of the Planck length, 10^{-33} cm. The energy density is enormous, 10^{93} g/cm^3. As the orthogonal flux passes through our space, the mini holes are constantly being created and destroyed in a chaotic maelstrom called the "quantum foam." Vorticity in the flow would manifest as elementary particles. A directional bias in the flow would manifest as vacuum polarization. In this model the elementary particles are like whirlpools sustained by the fourth dimensional flux. Wheeler's geometrodynamics is perhaps the most powerful of the ZPE theories, and if we could find a means to control and coherently channel some of that orthogonal flux into our three space, novel technologies to tap appreciable energy as well as control inertia or gravity might be possible.

VACUUM POLARIZATION

The technical question becomes how can we most influence the ZPE flux? Quantum electrodynamics shows that the different elementary particles have different vacuum polarization interactions with the zero-point energy [9]. In particular, electrons, especially in standard conductors, are effectively in equilibrium with the zero-point fluctuations and manifest the entire interaction as a distributed electron cloud [10]. No net vacuum energy absorption could be expected from standard conductors and antennas. Nuclei on the other hand exhibit steep lines of vacuum polarization converging onto the particle. Whenever nuclei undergo abrupt motion or collisions, appreciable vacuum polarization effects occur yielding precipitation of new particles as well as exotic coherent vacuum states [11]. Plasmas during ion-acoustic resonance have exhibited energetic anomalies [12] whose source could be a coherent macroscopic vacuum polarization [13, 14] across the plasma. Recent analysis [15] has shown that the abrupt motion of a dielectric boundary triggers real photons from the ZPE into existence. The energy production is proportional to the fourth derivative of the dielectric's velocity, which is an indication that the motion must be sharply abrupt. Sharp, abrupt motion of matter is a technical key to tapping the zero-point energy.

SONOLUMINESCENCE

Eberlein [16] extended her analysis of a dielectric boundary's interaction with the ZPE to explain sonoluminescence, a phenomena where a 50 picosecond light pulse is triggered by a collapsing air bubble in water excited by ultrasonics [17]. An abrupt squeeze and release is provided by the bubble's dielectric boundary which exhibits an appreciable fourth derivative of velocity at the turn-around point (minimum radius) where the surface changes direction. The sharp squeeze and release is similar to the proposal of using sharply pulsed, bucking electromagnetic fields to create a pulsed scalar excitation, which induces a slight "orthorotation" (twisting) of the fourth dimensional ZPE flux into our three dimensional space [18]. Sonoluminescence uses the nuclei in the polarized dielectric, bubble boundary to provide the bucking (scalar) squeeze field. The abrupt, noninertial movement of matter, especially plasma nuclei, appears to be an excellent activator of the vacuum energy.

The trick now is to absorb that energy. Eberlein's study of single bubble sonoluminescence shows that even though the emitted spectrum appears similar to a blackbody radiator at 40,000° Kelvin, it is not a high temperature phenomenon, but rather is an artifact of the ZPE spectrum in its interaction with the bubble boundary. (The artifact might even be expected in view of Boyer's calculation [4] showing how the blackbody spectrum can be derived from the ZPE spectrum). In particular, the lower frequency components of the blackbody spectrum are absent, which result in little interaction with the water to form heat or produce molecular disassociation. The absence of plasma recombination emissions or ion radicals in the single bubble experiments support the thesis that heat is not being produced [16]. Thus, even through we are activating the vacuum energy into light pulses, the light propagates away, unless we arrange for a means to absorb it.

RESONANT ABSORPTION

Eberlein's analysis shows that the bubble at its minimum radius (about one micron) does exhibit a resonant interaction with the emissions causing an enhancement by a factor of a thousand. Creating a resonant absorber is another key, especially if the high frequency energy can be converted to a more useful form. Perhaps Mead's [19] nonlinear, microscopic resonators designed to absorb very high frequency ZPE fluctuations and emit low beat frequencies would respond well if it were in contact with the bubbles. Inducing a plasma in the water might likewise provide the opportunity for resonant absorption. Meyer [20] used multiple excitation methods (electromagnetic, light, and ultrasonics) simultaneously to dissociate water, and Puharich [21] electrically stimulated water at the resonant frequency of its hydrogen-oxygen bond to dissociate it. Both inventors induced a plasma in water electrically excited at frequencies in the ultrasonic band and claimed a net energy gain in their systems. Inducing turbulence and cavitation in water might also produce plasma yielding a resonant interaction and absorption of ZPE. Griggs [22] claims to produce heat in excess of his input energy via cavitation in his hydrosonic pump, and Keely [23] claimed excess energy in his water motor based on a turbulent operation similar to water hammer vibrations. Schauberger [24] likewise claimed anomalous energy by causing water to flow in a precessional, turbulent manner through carefully crafted pipes where the flow manifested a characteristic bluish glow akin to sonoluminescence. Also there are cold fusion projects using ultrasonic stimulation producing excess heat [25, 26]. Direct evidence for plasma phenomena in water was recorded by Matsumoto [27] where tracks of a small plasmoid (like ball lightning) were photographed. If boundary conditions or turbulence can deform a spherical sonoluminescent bubble toward a pancake shape [28], the center could pinch and transform it into a plasmoid vortex ring [29]. Plasmoids [30] just might be an ideal resonant absorber of the zero-point energy.

PLASMOIDS

Plasmoid was the name given by Bostick [31] for a stable, plasma vortex ring he created with abrupt electric discharges. His studies indicated that the plasmoid particles would flow in a helical fashion with the helix closing onto itself producing a toroid. The plasmoid particles undergo a precessional motion (a spin of a spin) with a poloidal spin closing into a toroidal spin. Could such a flow be a natural orthorotator of the four dimensional ZPE flux? DePalma's study [32] of forced precession in a mechanical system exhibited gravitational and inertial anomalies. If the ZPE is the basis of inertia, then it would likewise be the basis of angular momentum. Since systems normally resist precessional motion, a force-free system exhibiting precession would be surprising. If such a system alters the ZPE flux, then it might seem to inertially disconnect from the three space universe, a sort of "Machian" disconnection. (Mach originally proposed the principle that the basis of inertia was the gravitational influence of the "fixed stars"). Moreover such a system would contain excess energy provided from the ZPE flux. Could the ZPE - plasma system have a natural stability in the vortex ring form? Reed [33] has suggested that the mathematical modeling by Beltrami of the force-free vortex might provide the engineering foundation for manipulating the ZPE. The force-free

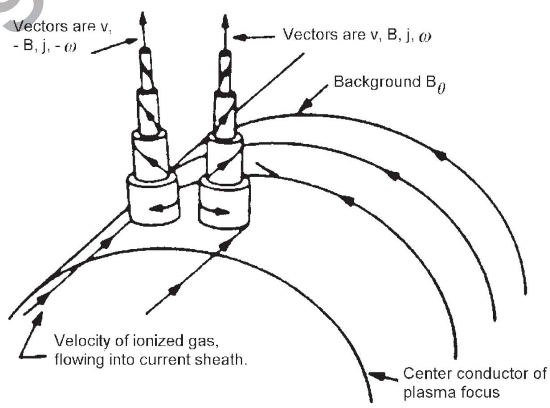


Fig. 1 Counter rotating plasma vortex filaments.

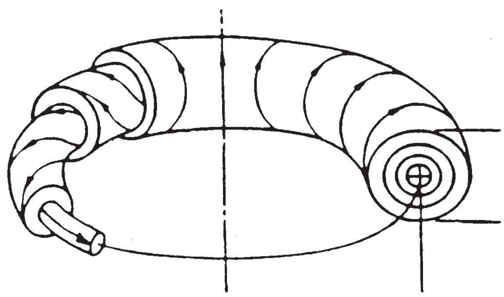


Fig. 2 Helical flow in plasmoid vortex ring.

vortex can taper like a tornado and concentrate an extreme energy density toward a point, making it a potentially good activator for ZPE coupling. Such vortex filaments have been observed in plasmas (known as the "filamentation instability" [34, 35, 36], and they tend to occur in counter-rotating pairs [37] (Fig. 1). Bostick also observed plasmoids to be formed in pairs with opposite helicity arising from plasma turbulence. Could such a model be archetypal and likewise represent vacuum polarization pair production from the turbulent "virtual plasma" of the quantum foam? [38, 39, 40] The vortex filament from a violent electrical discharge has been observed to sometimes form rings [41] (Fig. 2), which has been suggested to be the basis of ball lightning formation. Ball lightning has also been modeled as a vortex ring [42], and its anomalous energy content suggest that it might be cohering the zero-point energy [43, 44]. A careful investigation could occur if we could reliably reproduce ball lightning in the laboratory.

CHARGE CLUSTERS

It appears that a phenomenon like a miniature form of ball lightning has been discovered and is reproducible in the laboratory. Shoulders [45] has shown that impressing a sharp, negative pulse through a pointed cathode in contact with a dielectric positioned on top of a plate anode (Fig. 3) launches a micron sized, negatively charged cluster that he named "Electrum Validum" (EV). Mesyats [46] claimed the same discovery and named it an "Ecton." Historically, Le Duc [47] documented this phenomena in his research predating 1900. Shoulders has measured that the one micron diameter EV contains approximately 10^{11} electrons and 10^{6} ions. When launched, it typically travels at a velocity about one tenth the speed of light. Shoulders has shown that when an EV strikes an anode it produces an electrical pulse which contains more energy than it took to create it. Moreover, when the EV passes through a coil (or in parallel to a serpentine shaped conductor), a pulse is induced on the coil which also exhibits a greater energy output than the original input. Shoulders and Puthoff [48] suggest that the excess energy is from the ZPE. Mesyats shows that the Ecton is launched as a result of an explosive emission from the cathode tip. Just prior to the emission the cathode melts, and an extremely sharp, liquid jet extends from it. The explosion destroys the sharp tip of the electrode, and it is difficult to reuse it to launch another ecton. Shoulders uses liquid metal (e.g. mercury) to maintain the tip and thus keeps it a source for repeatable launching. Shoulders also covers the cathode by a hollow dielectric shroud (Fig. 4) designed to separate the EV from all the residual ions in the explosive emission. In addition the shroud might offer another possibility to enhance the effect. Mesyats has shown that a surface plasma on the dielectric amplifies the explosive emission. If Shoulders' shroud could be used like a hollow cathode electrode [49] that accumulates a glow plasma just before firing, the explosive emission through the glow plasma might launch a larger and even more powerful EV.

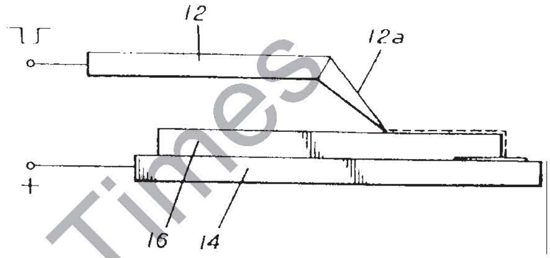


Fig. 3 Launching EV plasmoid from sharp pointed cathode (12a) in contact with dielectric plate (16) on top of metal anode (14).

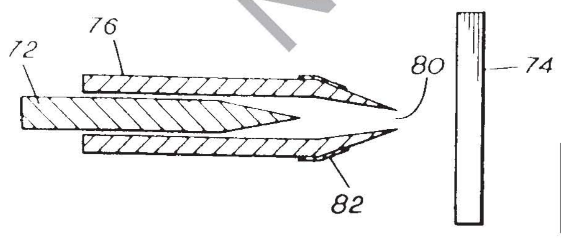


Fig. 4 Cross section of cylindrical EV launcher. Dielectric shroud (76) surrounds pointed cathode (72) firing EV toward anode (74). Electrode band (82) is charged to half the anode voltage to repulse ions such that only the negative EV's are launched through the aperture (80).

Experimental support for empowering the EV from a glow plasma may arise from the research of Correa [50] whose tubes are designed to build up a cathode glow which then pulses, a phenomenon known as the "abnormal glow discharge." Correa provides a circuit to restrict the current such that the lossy, vacuum arc discharge that follows is immediately quenched, and causes the tube to pulse at a chosen repetition rate. Correa has measured a significant over unity energy gain from his tubes, and has likely rediscovered the operating principle of the plasma tubes of Moray [51, 52]. The research of Mesyats supports the conjecture that the abnormal glow discharge can launch EV's, and these are likely the source of the energy anomalies in inventions that involve electric discharges.

The theoretical stability of EV's presents difficulties. A simple spherical model of 10^{11} electrons would fail due to Coulomb repulsion. Ziolkowski and Tippett [53] proposed a collective plasma system interacting with localized electromagnetic waves. The analysis uses a vacuum polarization displacement current term that manifests a sort of "quantum potential" that compensates for the expansion forces. Such a term is significant only if the formation time of the EV is on the order of a femto second (10^{-15} sec). The analysis involves plasma flow vorticity, but it is not clear what geometry the flow takes. Jin and Fox [54] have proposed a toroidal vortex ring using a classical, nonrelativistic analysis of a non-neutral plasma. They show that a launched spherical charge distribution would not be stable, but rather would naturally pinch into a vortex ring. The analysis attempts to show that the poloidal rotation of the vortex ring could produce a large enough magnetic field to attract the outer circulating electrons in a diocotron [36] slipping stream flow. The poloidal rotational velocity would have to be extraordinary, and the stabilizing ring would have to be an extemely thin filament to keep the poloidal electron velocities well below the speed of light. The calculated energy densities within the filament would be greater than a neutron star. At such energy densities vacuum polarization effects would come into play and should really be included in the model. Also the EV's polarization interaction with the dielectric guide is a stabilizing factor and should likewise be included. A classical, nonrelativistic analysis is probably not sufficient to accurately model the EV. Nonetheless, the suggestion that a thin filament vortex ring is the underlying geometry of the EV can be supported from studying the filamentation instability whose imploding, tightening tendency is recognized to produce extremely high energy densities. Since quantum electrodynamic effects are significant at high energy densities, a complete model of the EV should also include a spectral interaction with the zero-point energy since the thin plasma filament would exhibit a resonant coupling with the short wave length, high frequency, and thus more energetic portion of the ZPE spectrum.

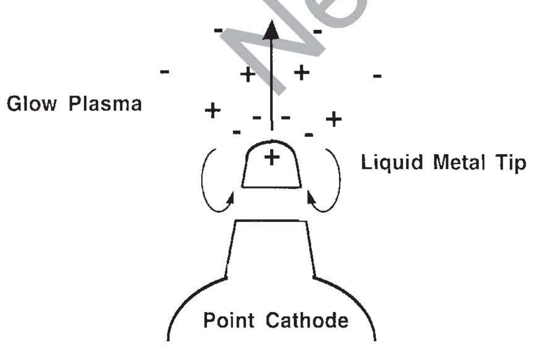


Fig. 5 Explosive emission launches charge cluster vortex ring. The emitted electron cloud experiences an abrupt compression between two symmetric ion boundaries: The ions of the glow plasma rushing toward the sharp pointed cathode and the ions of the ejected tip of the liquid metal cathode protruberance.

It appears that the ions in the polarized glow plasma and the exploding liquid metal cathode tip combine to create an abrupt compression that forms and energizes the charge cluster vortex ring. Just prior to the explosive emission, the polarized glow plasma and the polarized liquid metal protruberance form two symmetric boundary layers surrounding the surface electrons. The explosive emission launches the surface electrons as well as the metal-tip ion boundary layer (Fig. 5). The emitted electron cloud then experiences a tremendous explosive compression between the two symmetric ion layers. The metal tip, ion layer punches through the glow plasma layer, creating turbulence which initiates the poloidal rotation of the vortex ring. The perfect boundary symmetry from the liquid protuberance and glow plasma not only causes an abrupt scalar compression which polarizes the vacuum and orthorotates the ZPE flux, but it also provides the needed boundary conditions to create a tight vortex filament that is closed upon itself trapping the excess energy.

Shoulders' observations of the EV's support the conjecture that they are like vacuum energy pumps. As the EV propagates down a dielectric guide, it is constantly ionizing the dielectric surface, emitting electrons and emitting light. Yet the EV does not decay. It yields the same pulse when it hits the anode regardless of the distance it travels in the guide. Also, when the high velocity EV triggers a pulse on a surrounding coil, it likewise does not decay. Moreover, the output pulse from the coil exceeds the input pulse that originally launched the EV. The EV must keep moving to remain stable, and seems to "feed" from its environment, absorbing electrons preceding it and shedding electrons in its wake.

NUCLEAR TRANSMUTATION

When the EV strikes the anode it damages the plate leaving small craters. Some craters exhibit a wider, explosive characteristic and these contain a further surprise: X-ray microanalysis of the crater show a wide range of elements that were not present before the strike, implying that the EV induced nuclear transmutations [55, 56]. Shoulders has proposed that since the EV can carry about 10^6 ions (or protons in a hydrogen gas experiment), it can accelerate the protons with sufficient kinetic energy to overcome the Coulomb barrier and penetrate the lattice nuclei triggering transmutation events. A classical calculation [57] supports Shoulders' hypothesis. The microanalysis of a palladium target showed magnesium, calcium, silicon, gallium and gold, all from a single EV strike. Shoulders has named the EV carrying nuclei, "Nuclear Electrum Validum" (NEV). The NEV's are created whenever the deuterium loaded palladium (or hydrogen loaded nickel) cracks internally producing the NEV by fracto-emission. Fracto-emission [58] has been observed to produce light emissions in experiments where a crystal is cracked. The emissions exhibit an anomalous persistence, sometimes for hours. Fracto-emission is akin to earthquake lights where a phenomenon like ball lightning arises from an earthquake fissure. The hypothesis that fracto-emission of NEV's is the energy source behind cold fusion gains further support from the fact that the anomalous heat in the bulk palladium experiments does not arise immediately after loading the palladium to saturation (it only takes three hours), but rather occurs after hundreds of hours, and then in bursts [59]. Like sonoluminescence, the cracking event is an extremely abrupt microscopic motion. The abrupt motion of the lattice nuclei can produce charged, dendritic edges ideal for EV production. If EV's are produced in the cold fusion experiments, then they might not only be the source behind the transmutation events, but could also produce excess heat directly upon exploding. Thus, the source of the excess heat in the cold fusion experiments [60] might be predominantly from the zero-point energy.

FRACTO-EMISSION

Fracto-emission on the interior of a dielectric might offer a means to trap and perhaps directly electrically couple to the EV. Mesyats notes that dielectric breakdown is often a launcher of EV's. In T.T. Brown's electrogravitic experiments [61, 62], where a charged capacitor exhibits an acceleration in the direction of the positive plate, the greatest thrusts were observed during dielectric breakdown. Lambertson's [63] ceramic/metallic composite might likewise have a fracto-emission phenomena occurring within it to produce excess energy in his experiments. A possible hypothesis to explain the voltage overshoot and excess energy in Hyde's [64] generator might involve fracto-emission within the dielectric spacers between the segmented stator elements. Also, Moray [51] used exotic and radioactive materials with his cold cathodes to produce surface, luminescent glow emissions. Could fracto-emission also be involved?

The fracto-emission plasma hypothesis has been proposed [39] to explain the anomalous energy production from a specially conditioned block of barium ferrite, in Sweet's [65] "Vacuum Triode Amplifier" (VTA), a well-witnessed, seemingly simple, self-running "free energy" device. The hypothesis has gained further support from new information on the process of conditioning the barium ferrite, and offers the opportunity for further replication by others. Sweet's conditioned barium ferrite (typically 6 x 4 x 1 inch ceramic blocks) exhibited the peculiar ability to shift its magnetic field in response to a very weak magnetic stimulation. This is unusual because the magnetic domains in barium ferrite do not readily move, especially after being conditioned like a permanent magnet. Another peculiarity was the tendency for the field motion to resonate at 60 Hertz (or any other intended frequency imprinted via the conditioning process). The conditioning steps [39] involved first driving the barium ferrite at 60 Hertz (2 amps) via a coil (600 turns of No. 28 wire) surrounding its perimeter, and then abruptly pulsing the coil from a charged capacitor (6500 microfarads at 450 volts). The pulse is fired at the peak of the 60 Hertz waveform. Also, the ceramic block was sometimes sandwiched between charged plates to impress a 20 kilovolt electrostatic potential across it during the conditioning process. No investigator claimed success in replication until one [66] tried a preliminary step: First dip the barium ferrite ceramic block into liquid nitrogen. Then the other conditioning steps could induce multiple cracks in the ceramic, loosening its grains. The easily moved, magnetic fields would occur due to pivoting grain motion (not magnetic domain motion), and such grain motion could be constantly creating and stimulating fracto-emission plasmoids trapped within the cracks. (The plasmoids would tend to persist because barium ferrite has a low conductivity and acts like a dielectric.) Sweet used pickup coils above the ceramic to receive the anomalous energy that would be produced when the ceramic block was driven by a weak 60 Hertz magnetic field from the side. If the fracto-emission hypothesis applies, Sweet may have discovered an elegant way to magnetically couple to EV plasmoids trapped within a dielectric and extract excess energy from them.

SPARKING DEVICES

Perhaps the most common way to extract energy associated with EV's is to absorb their pulses when they hit the anode. Shoulders has shown that the EV's tend to be the first portion of the plasma launched in discharge events. Correa has shown likewise: the anomalous excess energy only occurs from the anomalous glow discharge, the precursor to the lossy vacuum arc discharge. Pappas [67] has proposed that electric sparks produce excess energy, a hypothesis seemingly confirmed by Shoulders and Correa, if the spark is of short duration. Dufour [67] has also observed excess heat produced from sparks in his "cold fusion" experiment involving a pure hydrogen gas tube with stainless steel electrodes. Anomalous energy production seems to also occur in underwater carbon arc discharge experiments [69] that produce the hydrocarbon fuel COH_2. Newman's [70] large discharging coil and Gray's [71] motor both exhibit abrupt sparking phenomena, and both inventors have claimed excess energy production. The Swiss ML Converter [72] is a famous, self-running energy invention involving counter rotating acrylic disks (segmented like a Wimshurst machine) that produces a bright corona between the disks. Could the corona plasma be comprised of EV's who yield their energy by discharging into the rectifier circuit? Rectifying and efficiently absorbing the energy of large voltage spikes, like those produced by EV anode strikes, is a challenging engineering task. If solved, it could facilitate direct electrical energy conversion in any device where abrupt electric discharges (and

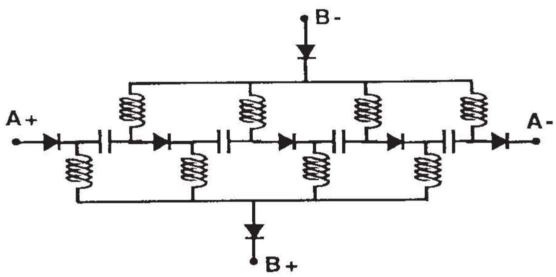


Fig. 6 Pulse Current Multiplier (PCM) converts unipolar voltage spikes (input on the A terminals) to current pulses (output on the B terminals). Four stages are shown, but in practice ten or more should be used.

EVproduction) are occurring.

A pulse current multiplier (PCM) circuit (Fig. 6) has been proposed [52] as a means of converting low power, but extemely high voltage spikes into lower voltage, higher current, wider width pulses that could be rectified by standard circuits. The PCM is similar to a standard voltage divider circuit where a bank of capacitors are charged in series and discharged in parallel. Instead of switches, blocking inductors are used to guide the input voltage spikes down the low impedance series path. The PCM circuit allows the efficient conversion of weak, electrostatic voltage spikes which, if summed in sufficient quantity, could produce abundant energy as demonstrated by the invention of Hyde [64]. If EV phenomena occur in all electrostatic discharges, then the PCM could provide an efficient method for converting the high voltage discharges and might provide the foundation for a practical device to tap the zero-point energy.

SUMMARY

Despite the beliefs of most of the scientific community, modern physics has accepted that empty space is filled with energetic electromagnetic fluctuations called the zero-point energy. The most powerful model has the ZPE source as a flux from hyperspace. All matter interacts with the ZPE and generally is in equilibrium with it. However, when abrupt matter motion occurs, especially with nuclei, some of the ZPE flux is twisted into our space and can manifest excessive energy. Sonoluminescence may be an example of trapping the energy in a short lived, microscopic resonant structure. The energy may likewise be trapped in microscopic vortex ring plasmoids called EV's. The plasmoid vortex ring might be a natural, resonant orthorotator of the ZPE flux which would cause it to behave like a vacuum energy pump. Since EV's appear to be a precursor within any electric discharge, they may be the source behind the "free energy" machines involving electrical discharges. The excess energy would manifest as high voltage spikes, and an efficient way to convert the spikes to a more useful waveform is by use of a pulse current multiplier circuit. Thus the ZPE coherence induced by the EV could be output directly as electricity.

Long-lived EV plasmoids could be produced during fracto-emission. They have been proposed to be the cause of excess heat as well as transmutation in the cold fusion experiments. EV's could carry and accelerate ions with sufficient kinetic energy to penetrate the Coulomb barrier of target nuclei, and thus act as microscopic particle accelerators to cause the transmutation of the lattice nuclei. Trapping EV's via fracto-emission within the interior of a dielectric might be the most efficient method for extracting their energy since they would tend to persist. Conditioning a barium ferrite ceramic block to maximize internal cracking to promote fracto-emission might be the key to replicating Sweet's self-running energy device. If other researchers become successful in reproducing the barium ferrite conditioning, it would set the stage for widespread replication of perhaps the simplest "free energy"' device ever invented. Whether EV's trigger pulses on nearby coils, strike anode plates, or get trapped within a dielectric, they appear to provide a unifying hypothesis to explain a wide range of energy devices whose source is apparently from the zero-point energy.

REFERENCES

1. P.A. Dirac (1930), Roy. Soc. Proc. 126, p 360. Also G. Gamow (1966), Thirty Years that Shook Physics, Double Day, NY.
2. R.P. Feynman (1985), QED The Strange Theory of Light and Matter, Princeton Univ. Press, Princeton, N.J.
3. T.H. Boyer (1975), "Random Electrodynamics: The Theory of Classical Electrodynamics with Classical Electromagnetic Zero-Point Radiation," *Phys. Rev. D,* vol 11, no 4, pp 790-808.
4. T.H. Boyer (1969), "Derivation of Blackbody Radiation Spectrum without Quantum Assumptions," *Phys. Rev.*, vol 182, no 5, pp 1374-83.

5. H.E. Puthoff (1987), "Ground State of Hydrogen as a Zero-Point Fluctuation Determined State," *Phys. Rev. D*, vol 35, no 10, pp 3266-69.
6. H.E. Puthoff (1989), "Gravity as a Zero-Point Fluctuation Force," *Phys. Rev. A*, vol 39, no 5, pp 2333-42.
7. B. Haisch, A. Rueda, H.E. Puthoff (1994), "Inertia as a Zero-Point Field Lorentz Force," *Phys. Rev. A*, vol 49, no 2, pp 678-694.
8. J.A. Wheeler (1962), Geometrodynamics, Academic Press, N.Y.
9. F. Scheck (1983), Leptons, Hadrons and Nuclei, North Holland Physics Publ., NY, pp 213-223.
10. I.R. Senitzky (1973), "Radiation Reaction and Vacuum Field Effects in Heisenberg-Picture Quantum Electrodynamics," *Phys. Rev. Lett.*, vol 31, no 15, p 955.
11. L.S. Celenza, V.K. Mishra, C.M. Shakin, K.F. Liu (1986), "Exotic States in QED," *Phys. Rev. Lett*, vol 57, no 1, p 55; D.G. Caldi, A. Chodos (1987), "Narrow e^+e^- Peaks in Heavy-Ion Collisions and a Possible New Phase of QED," *Phys. Rev. D*, vol 36, no 9, p 2876; Jack Ng, Y. and Y. Kikuchi (1987), "Narrow e^+e^- Peaks in Heavy-Ion Collisions as Possible Evidence of a Confining Phase of QED," *Phys. Rev. D*, vol 36, no 9, p 2880; L.S. Celenza, and C.R. Ji, C.M. Shakin (1987), "Nontopological Solitons in Strongly Coupled QED," *Phys. Rev. D*, vol 36, no 7, pp 2144-48.
12. J.D. Sethian, and D.A. Hammer, C.B. Whaston (1978), "Anomalous Electron-Ion Energy Transfer in a Relativistic-Electron-Beam Heated Plasma," *Phys. Rev. Lett*, vol. 40, no 7, p 451; S. Robertson, A. Fisher, C.W. Roberson (1980), "Electron Beam Heating of a Mirror Confined Plasma," *Phys. Fluids*, vol 32, no 2, p 318; M. Tanaka, Y. Kawai (1979), "Electron Heating by Ion Acoustic Turbulence in Plasmas," *J. Phys. Soc. Jpn.*, vol 47, no 1, p 294.
13. M.B. King, (1984), "Macroscopic Vacuum Polarization," Proc. Tesla Centennial Symp., International Tesla Society, Colorado Springs, pp 99-107. Also (1989), Tapping the Zero-Point Energy, Paraclete Publishing, pp 57-75.
14. E.A. Rausher (1968), "Electron Interactions and Quantum Plasma Physics," *J. Plasma Phys.*, vol 2, no 4, p 517.
15. G. Barton, C. Eberlein (1993), "On Quantum Radiation from a Moving Body with Finite Refractive Index," *Ann. Phys*, vol. 227, pp 222-274.
Theoretical analysis of matter in motion interacting with the ZPE. Real photons from the ZPE are created via abrupt motion.
16. C. Eberlein (1996), "Sonoluminescence as Quantum Vacuum Radiation," *Phys. Rev. Lett.*, vol 76, pp 3842-45; (1996), "Theory of Quantum Radiation Observed as Sonoluminescence," *Phys. Rev. A*, vol 53, pp 2772-87.
Theory that sonoluminescence energy is from a resonant interaction with the ZPE.
17. B.P. Barber, and S.J. Putterman (1991), "Observation of Synchronous Picosecond Sonoluminescence," Nature, vol 35, no 3, pp 318-320;.. (1992), "Light Scattering Measurements of the Repetitive Supersonic Implosion of a Sonoluminescing Bubble," *Phys. Rev. Lett.*, vol 69, pp 3839-42.
18. M.B. King, (1986), "Cohering the Zero-Point Energy," Proc. of the 1986 International Tesla Symp., Colorado Springs, section 4, pp 13-32. Also (1989), Tapping the Zero-Point Energy, Paraclete Publishing, pp 77-106.
19. F.B. Mead, (1996), "System for Converting Electromagnetic Radiation Energy to Electrical Energy," U.S. Patent 5,590,031; printed in *Infinite Energy*, vol 2, no 11, pp 29-34.
System of pairs of microscopic resonators tuned to the high frequency modes of the ZPE. The pairs interact and are tuned to slightly different frequencies so as to emit the beat, difference frequency, which could readily be absorbed by standard circuits. Arrays of microscopic resonators might allow a practical, solid state method to tap the ZPE.
20. S.L. Meyer (1991), The Birth of a New Technology, Water Fuel Cell, Grove City, OH; ... (1989), "Controlled Process for the Production of Thermal Energy from Gases and Apparatus Useful Therefore," U.S. Patent No. 4,826,581;... (1990), "Method for the Production of a Fuel Gas, (Electrical Polarization Process)," U.S. Patent No. 4,936,961.
21. A. Puharich (1981), "Water Decomposition by Means of Alternating Current Electrolysis," Proc. First International Symp. Nonconventional Energy Technology, Toronto, pp 49-77; ... (1983), "Method and Apparatus for Splitting Water Molecules," U.S. Patent No. 4,394,230.
22. J. Rothwell (1996), "Notes on the Talk by James Griggs of Hydro Dynamics, Inc. at the Cold Fusion & New Energy Symp., January 20, 1996," *Infinite Energy*, vol 1, nos 5 & 6, pp 25-27.
23. D. Pond (l994),"The Keely Motor - How It Works," Proc. Int. Symp. New Energy, pp 359-371.
24. O. Alexandersson (1990), Living Water: Viktor Schauberger and the Secrets of Natural Energy, Gateway Books, Bath, UK. Also, B. Frokjaer-Jensen (1981), "The Scandinavian Research

Organization and the Implosion Theory (Viktor Schauberger)," Proc. First International Symp. Nonconventional Energy Technology, Toronto, pp 78-96.
25. T. Bensen (1995), "A Micro-Fusion Reactor: Nuclear Reactions in the Cold by Ultrasonic Cavitation," *Infinite Energy*, vol 1, no 1, pp 33-37.
Summarizes the invention of R. Stringham and R. George that uses ultrasonic cavitation to induce cold fusion in palladium foil in heavy water. Excess beat and helium are produced. Electron microscope photos of the foil show pock marks of melted and recooled metal.
26. S.K.H. Auluck, V.K. Shrikande (July 1995), "Proposal for Replication of Stringham and George's Ultrasonic Cavitation Experiment," *Fusion Facts*, vol 7, no 1, pp 9-10.
Discusses a pancake collapse model of a sonoluminescent bubble. It can launch a high velocity jet which can inject the contents of the bubble into any solid surface to which it has contact.
27. T. Matsumoto (1996), "Extraordinary Traces Produced during Pulsed Discharges in Water," *Cold Fusion*, Issue 9, pp 17-21; ...(April 1995), "Artificial Ball-Lightning - Photographs of Cold Fusion," ICCF-5, abstract in *Fusion Facts*, vol 6, no 10, pp 24-25; ...(May 1995), "Cold Fusion Experiments by Sparking Discharges in Water," ICCF-5, abstract in *Fusion Facts*, vol 6, no 11, p 28.
Observation of tiny ball lightning phenomena in under water discharges for cold fusion experiments. Proposes the formation of hydrogen clusters to induce the fusion events.
28. T.V. Prevenslik, (1996), "Planck Energy and Biological Effects of Ultrasonic Cavitation," *Cold Fusion* Issue 11, pp 7-10; ...(February 1996), "Biological Effects of Ultrasonic Cavitation," *Fusion Facts*, vol 7, no 8, pp 8-9; ...(July 1996), "Ultrasound Induced and Laser Enhanced Cold Fusion Chemistry," *Fusion Facts*, vol 8, no 1, pp 15-16.
Model for sonoluminescence has a spherical bubble collapsing into a pancake shape. Zero-point energy modes cohere sufficiently to dissociate water molecules.
29. C. Bennett (1996), "A Theoretical Mechanism for Sonofusion," *Cold Fusion*, Issue 18, pp 40-42.
Hypothesis that a sonoluminescent bubble collapses into a toroidal vortex ring. Particles accelerated through the center of the vortex have sufficient kinetic energy to generate fusion.
30. E.H. Lewis (1995), "Tornados and Ball Lightning," *Extraordinary Science*, vol 7, no 4, pp 3337; ...(March 1996). "Tornados and Tiny Plasmoid Phenomena," *New Energy News*, vol 3, no 9, pp 18-20;...(Feb 1994), "Some Important Kinds of Plasmoid Traces Produced by Cold Fusion Apparatus," *Fusion Facts*, vol 6, no 8, pp 16-17; ...(October 1996), "The Plasmoid Theory," *Cold Fusion*, Issue 19, pp 37-44; ...(May 1995), "Plasmoid Phenomena," *New Energy News*, vol 2, no 12, pp 9-10.
Overview of plasmoid phenomena including tornados, ball lightning, and microscopic EV's. Includes an abundant list of references.
31. W.H. Bostick (1957), "Experimental Study of Plasmoids," *Phys. Rev.*, vol 106, no 3, p 404; ...(October 1957), "Plasmoids," *Scientific American*, vol 19, no 27, p 87.
32. B.E. DePalma C.E. Edwards (1973), "The Force Machine Experiments," privately published.
33. D. Reed (1992), "Toward a Structural Model for the Fundamental Electrodynamic Fields of Nature," *Extraordinary Science*, vol 4, no 2, pp 22-33; ... (1993), "Evidence for the Screw Electromagnetic Field in Macro and Microscopic Reality," Proc. Int. Symp. New Energy, pp 497-510; ... (1994), "Beltrami Topology as Archetypal Vortex," Proc. Int. Symp. New Energy, pp 585-608; ...(1996), "The Beltrami Vector Field - The Key to Unlocking the Secrets of Vacuum Energy?" Proc. Int. Symp. New Energy, pp 345-363.
34. V. Nardi, W.H. Bostick, J. Feugeas, W. Prior (1980), "Internal Structure of ElectronBeam Filaments," *Phys. Rev. A*, vol 22, no 5, pp 2211-17.
35. G. Benford (1972), "Electron Beam Filamentation in Strong Magnetic Fields," *Phys. Rev. Lett.* vol 28, no 19, pp 1242-44; R. Lee, M. Lampe (1973), "Electromagnetic Instabilities, Filamentation and Focusing of Relativistic Electron Beams," *Phys. Rev. Lett.*, vol 31, no 23, pp 1390-93; C.A. Kapetankos (1974), "Filamentation of Intense Relativistic Electron Beams Propagating in a Dense Plasma," *App. Phys. Lett.*, vol 25, no 9, pp 484-488.
36. R.C. Davidson (1990), Physics of Nonneutral Plasmas, Addison-Wesley, NY.
Complete introduction to the topic of nonneutral (or charged) plasmas with abundant references to the scientific literature. The text provides the foundation for the mathematical modeling of nonneutral plasmas.
37. W.H. Bostick (1966), "Pair Production of Plasma Vortices." *Phys. Fluids*, vol 9, pp 2078-80.
38. A.E. Akimov, G.I. Shipov (June 1996), "Torsion Fields and Their Experimental Manifestation," Proc. Int. Sci. Conf. on New Ideas in Natural Science, St. Petersburg Russia. Summarized by A. Frolov (March 1997), *New Energy News*, vol 4, no 11, pp 12-14.

Torsion fields are a model of the physical vacuum similar to Dirac's model except it is comprised of annular wave packets of electrons and positrons instead of electron-positron pairs. Under appropriate conditions the polarized state of the vacuum can be turned into a spin field. Torsion field technology might allow tapping the vacuum energy, inertial propulsion and superluminal communication.

39. M.B. King (1994), "Vacuum Energy Vortices," Proc. Int. Symp. New Energy, pp 257-269.
Hypothesis is proposed that counter-rotating plasma vortices can induce a macroscopic pair production of vacuum polarization displacement currents, and such activity yields a large ZPE coherence. An analysis of Sweet's VTA device proposes that fracto-emission inside the barium ferrite ceramic (caused by the conditioning process) produces the plasma with grain pivoting inducing the counter-rotation.

40. F. Winterberg (1990), "Maxwell's Equations and Einstein-Gravity in the Planck Aether Model of a Unified Field Theory," *Z. Naturforsch.*, vol 45 a, pp 1102-16; ... (1991), "Substratum Interpretation of the Quark-Lepton Symmetries in the Planck Aether Model of a Unified Field Theory," *Z. Naturforsch.*, vol 46 a, pp 551-559.
A model of the aether comprised of dynamic, toroidal vortex rings.

41. I. Alexelf, M. Radar (1995), "Possible Precursors of Ball Lightning - Observation of Closed Loops in High-Voltage Discharges," *Fusion Tech.*, vol 27, pp 271-273.
Closed current loops were photographed during high voltage discharges. The loops enclose a magnetic field of very high energy density. They contract and quickly become compact force-free loops that superficially resemble spheres. In these toroidal geometries, the trapped internal magnetic field balances the external magnetic field to provide an almost force-free configuration. The bibliography cites numerous references on ball lightning.

42. P.O. Johnson (1965), "Ball Lightning and Self-Containing Electromagnetic Fields," *Am. J. Phys.*, vol 33, p 119.

43. G. Egely (1986), "Energy Transfer Problems of Ball Lightning," Cent. Res. Inst. for Phys., Budapest, Hungary.

44. M.B. King (1989), Tapping the Zero-Point Energy, Paraclete Publishing, Provo, UT; ... (1991), "Tapping the Zero-Point Energy as an Energy Source," Proc. 26th IECEC vol.4, pp 364-369; ... (1993), "Fundamentals of a Zero-Point Energy Technology," Proc. Int. Symp. New Energy, pp 201-217.

45. K.R. Shoulders (1991), "Energy Conversion Using High Charge Density," U.S. Patent No. 5,018,180.
Fundamental discovery on how to launch a micron size, negatively charged plasmoid called "Electrum Validum" (EV). An EV yields excess energy (over unity gain) whenever it hits the anode or travels down the axis of an hollow coil. The excess energy comes from the ZPE.

46. G.A. Mesvals (1996), "Ecton Processes at the Cathode in a Vacuum Discharge, Proc. 17th International Symp. Discharges & Electrical Insulation in Vacuum, pp 720-731.
Russian research is presented analyzing their discovery of charge clusters, called "ectons." Ectons often arise from micro explosions on the surface of the cathode, where surface imperfections such as micro protrusions, adsorbed gases, dielectric films and inclusions play an important role. The simplest way to initiate ectons is to cause an explosion of cathode micro protrusions under the action of field emission current. Experiments confirm micro protrusions jets can form from liquid or melting metal. The breakdown of thick dielectric films in their charging with ions also plays an important role in the initiation of ectons. A commonly used way to initiate an ecton is to induce a vacuum discharge over a dielectric in contact with a pointed metal cathode. An ecton can readily be excited at a contaminated cathode with a low density plasma, but a clean cathode requires a high plasma density.

47. S. Le Due (1908), Electric Ions and Their Use in Medicine, Rebman Co., London.

48. H.E. Puthoff (1990), "The Energetic Vacuum: Implications for Energy Research," *Spec. Sci. Tech.*, vol 13, no 4, pp 247-257.

49. M.A. Gundersen, G. Schaefer (1990), Physics and Applications of Pseudosparks, Plenum Press, NY.
Conference proceedings studying hollow cathode discharge phenomena. If a glow discharge is created in the interior of a hollow cathode, tremendous currents may be switched and triggered by a small external signal. The phenomena generates an intense beam of ions between the electrodes. The initial stage of the discharge exhibits anomalous behavior including a negative resistance characteristic that is a powerful version of the abnormal glow discharge.

50. P.N. Correa, A.N. Correa (1995), "Electromechanical Transduction of Plasma Pulses," U.S. Patent 5,416,391; "Energy Conversion System," U.S. Patent 5,449,989; ...(1996), "XS NRG^{TM} Technology," *Infinite Energy*, vol 2, no 7, pp 18-38.
Fundamental discovery that a plasma tube tuned to operate at the abnormal glow discharge region exhibits an over unity energy gain. The abnormal glow discharge is a glow plasma that surrounds the cathode just before a vacuum arc discharge (spark) that occurs when the tube is slowly charged with increasing voltage. The abnormal glow exhibits a negative resistance characteristic as the tube begins an arc discharge. The patents illustrate how 10 make an appropriate charging circuit 10 cycle the tube in the abnormal glow discharge regime, control the cycle frequency, avoid the losses of the vacuum arc discharge, and rectify the excess energy onto batteries.

51. T.H. Moray, J.E. Moray (1978), The Sea of Energy, Cosray Research Institute, Salt Lake City.

52. M.B. King (1996), "The Super Tube," Proc. Int. Symp. New Energy, pp 209-221; also *Infinite Energy*, vol 2, no 8, pp 23-28.
A powerful plasma tube intended to cohere the ZPE combines the use of a hollow cathode discharge, radioactive cathodes and inert gas mixtures; it operates in the abnormal glow discharge regime. Output energy in the form of large voltage spikes are efficiently absorbed by a pulse current multiplier (PCM) circuit which might offer a solid state means of tapping the vacuum energy.

53. R.W. Ziolkowski, M.K. Tippett (1991), "Collective Effect in an Electron Plasma System Catalyzed by a Localized Electromagnetic Wave," *Phys. Rev. A*, vol 43, no 6, pp 3066-72.
Mathematical analysis of Shoulder's EV that includes a significant (vacuum polarization) displacement current term since the EV formation time is of the same order as the plasma frequency period. The resulting nonlinear Klein-Gordon equation contains vorticity terms and a term similar to a quantum mechanical potential which compensates for the repulsion. The system is solved by numerical methods for a stable, localized wave solution which matches the EV in size and charge density.

54. S.X. Jin, H. Fox (1996), "Characteristics of High-Density Charge Clusters: A Theoretical Model," *J. New Energy*, vol 1, no 4, pp 5-20.
A mathematical model of charged clusters (Shoulder's EV's) is presented that shows the stability is due to a helical vortex ring possessing an extraordinary poloidal circulation. In this nonrelativistic calculation, the poloidal filament would have to be thin. A spherical electron cluster is unstable and would tend to form into a toroid by a force balance relationship. The calculation shows that the energy density of the poloidal filament in a charge cluster is a hundred times higher than in a supernova explosion.

55. K. Shoulders, S. Shoulders (1996), "Observations on the Role of Charge Clusters in Nuclear Cluster Reactions," *J. New Energy*, vol 1, no 3, pp 111-121.
Experimental evidence in the form of micrographs and X-ray microanalysis is presented suggesting that nuclear charge clusters, (micron sized plasmoids containing 10^{11} electrons and 10^{6} protons or deuterons) can accelerate into lattice nuclei with sufficient kinetic energy to overcome the Coulomb barrier and trigger transmutation events. The hypothesis to explain cold fusion is proposed where electrolytic loading of palladium or nickel causes cracking and fracto-emission of the charge clusters.

56. K. Shoulders, S. Shoulders (1997), "Charge Clusters," *Planetary Association for Clean Energy Newsletter*, vol 9, no 1, pp 13-17.
Overview of charge cluster research includes EV's produced by ultrasonics and cavitation charge separation.

57. H. Fox, R.W. Bass, S.X. Jin (1996), "Plasma-Injected Transmutation," *J. New Energy*, vol 1, no 3, pp 222-230.
Classical calculation showing that nuclear charge clusters can be produced at low energy and yet gain sufficient acceleration for their contained protons to penetrate the Coulomb barrier and transmute lattice nuclei.

58. G. Preparata (1991), "A New Look at Solid-State Fractures, Particle Emission and Cold Nuclear Fusion," *Il Nuovo Cimento*, vol 104 A, no 8, p 1259; ... (1990), "Quantum Field Theory of Superradiance," Problems of Fundamental Modern Physics, World Scientific, Singapore, R. Chembini, P. Dal Piaz, B. Minetti (editors).

59. J.O'M. Bockris (1996), "The Complex Conditions Needed to Obtain Nuclear Heat from D-Pd Systems," *J. New Energy*, vol 1, no 3, pp 210-218.

The hypothesis is proposed that internal cracking of the cathode palladium (or nickel) is the needed triggering mechanism to obtain cold fusion or transmutation events. It explains why, even though it takes only three hours to load palladium rods to saturation, there can be delays of hundreds of hours before heat bursts occur. If the cracks should reach the surface, the deuterium fugacity is diminished and the reaction stops. Thin palladium nickel alloys or layers, as in Patterson's beads, allow the internal cracking to occur quickly giving reliable and repeatable results.

60. J. Patterson (1996), U.S. Patent 5,494,559. J. Rothwell (1995), "Highlights of the Fifth International Conference on Cold Fusion," *Infinite Energy*, vol 1, no 2, pp 8-18.
The first U.S. "cold fusion" patent with the claim of excess energy (2000%) granted. The Patterson cell contains hundreds of sub millimeter beads made in a electroplating process of depositing multiple, alternating, thin layers of very pure nickel and palladium. It runs using a light water electrolyte. It is considered the best of the electrolytic cold fusion type of experiments with complete repeatability and a record gain of over 1000 in one demonstration.
61. T. Valone (1994), Electrogravities Systems, Integrity Research Inst., Washington DC.
62. M.B. King (1976), "Is Artificial Gravity Possible," Tapping the Zero-Point Energy, Paraclete Publishing, Provo, UT. pp 19-32.
63. W.A. Lambertson (1994), "History and Status of the WIN Process," Proc. Int. Symp. New Energy, pp 283-288.
64. W.W. Hyde (1990), "Electrostatic Energy Field Power Generating System," U.S. Patent No. 4,897,592.
The invention is summarized in King (1991), reference 44.
65. F. Sweet, T.E. Bearden (1991), "Utilizing Scalar Electromagnetics to Tap Vacuum Energy," Proc. 26th IECEC, vol. 4, pp 370-375; ... (1988), "Nothing is Something: The Theory and Operation of a Phase-Conjugate Vacuum Triode;" ... (1989), private communication.
66. D. Watson (1996), private communication.
67. P.T. Pappas (1991), "Energy Creation in Electrical Sparks and Discharges: Theory and Direct Experimental Evidence," Proc. 26th IECEC, vol. *4*, pp 416-423.
68. J. Dufour (1993), "Cold Fusion by Sparking in Hydrogen Isotopes," *Fusion Technology*, vol 24, pp 205-228.
69. E.F. Mallove (1996), "AquaFuel and COH_2 Synthesis Gases - More Patents, New Measurements, Speculation..." *Infinite Energy*, vol 2, no 10, pp 32-44; "AquaFuel - A Wonderful Fuel, but is it Over-Unity?" *Infinite Energy*, vol 2, no 9, pp 44-48.
Carbon arcs underwater producing COH_2 fuel manifest over unity efficiency.
70. I. Newman (1984), The Energy Machine of Joseph Newman, Joseph Newman Publishing Co., Lucedale, MS. Review by M. Carrell (1996), *Infinite Energy*, vol 2, no 7, pp 54-58; special report by E. Soule, pp 58-61.
71. E.V. Gray (1976), "Pulsed Capacitor Discharge Electric Engine," U.S. Patent 3,890,548.
72. P.H. Matthey. (1985), "The Swiss ML Converter- A Masterpiece of Craftsmanship and Electronic Engineering," Revolution in Technology, Medicine and Society, MIT Verlag, Odenburg. H.A. Nieper (ed.),

COLD FUSION / COLD FISSION TO ACCOUNT FOR 'RADIATION REMEDIATION'

Robert T. Bush [1]

ABSTRACT

In a paper delivered at the Second Conference on Low-Energy Nuclear Reactions (College Station, Texas, 9/14/96) entitled "Some Theoretical Observations Upon Lattice-Assisted Nuclear Reactions in an Electrolytic Cell with Pd (Cathode) and Pt (Anode)," the author introduced a nuclear model (Bush [1]), which gave theoretical predictions in good agreement with the nuclear products and isotopic abundance shifts detected experimentally by T. Mizuno of Hokaido University for a Pd/Pt electrolytic cell (Mizuno et al. [2], [3]). The comparison with the Mizuno data [2] [3] is again presented here, and the model is now employed to account for the phenomenon of "radiation remediation" as observed by Gleason and Neal (Gleason, Neal [8]) of Morning Star, Inc., Cincinnati, Ohio.

EXPLANATION OF COLD FUSION AND COLD FISSION

Cold fusion and cold fission in this model are both catalyzed by electrons. In cold fusion a particle such as a proton, deuteron, or triton has its probability for quantum-mechanically tunneling into another nucleus vastly increased by the presence of an electron near enough to the positive charge so that the width and height of the Coulomb barrier are both reduced. [This author suggested in 1992 (Bush [5]) that electrons might well catalyze cold fusion reactions. In addition, that part of the author's Unifying Model presented in 1994 (Bush [6]) dealing with statistical mechanical considerations would likewise be applicable here. Also, Miley and Hora (Miley, Hora, et al.[7]) have suggested the importance of the effects of electron screening for cold fusion.]

In cold fission the number of electrons has been so increased over the cold fusion case that, at least charge-wise, some protons seem like neutrons. In essence, then, the resulting nucleus finds itself with too many "neutrons" for the number of protons present. Thus, the fissioning results in order to produce nuclear products that have neutron-to-proton ratios that place them nearer to the well-known nuclear stability curve.

Thus, "cold fusion" and "cold fission" might aptly also be termed, respectively, "electron-induced fusion" and "electron-induced fission." As it turns out, "lattice-assisted fusion" and "lattice assisted fission" are also appropriate. The higher the pressure, the higher could be the ambient temperature. What is required is a repeating structure such as a crystal, or quasi crystal in which the phenomena can occur. (A central mystery as to how electronic enhancement is achieved is part of a U.S. patent application of October, 1996, and is not being revealed for the time being.)

AGREEMENT WITH MIZUNO'S EXPERIMENTAL RESULTS

---

[1] Physics Department, California State Polytechnic Univ. at Pomona, 3801 West Temple Ave., Pomona, CA 91768.

[2] The present paper includes the material that would have appeared in the Proceedings of the Second Conference on Low-Energy Nuclear Reactions published in Fall 1996 in the *Journal of New Energy* had it been finished in time. The paper would have had the title of reference [1].

[3] A preview of the present paper has appeared in *Infinite Energy Magazine*, (Bush [9]).

The model accounts for the large amount of Xe produced in Mizuno's experiment (Mizuno et al. [2], [3]) by employing three principal reactions: (1) Cold fission of the platinum that plates over from the Pt anode onto the Pd cathode, (2) Cold fusion involving the addition of a deuteron to 1-134 and 1-129 to produce Xe-136 and Xe-131, respectively, and, (3) Cold fission of the Pd of the cathode.

The major stable products produced according to Mizuno ([2], [3]) are isotopes of Xe and Mg, with smaller amounts of K, Ca, Ar, Cl, and Ti. (At production, however, cannot be studied because of the fact that Ar ions are employed in the mass spectrometry.)

The model explains the production of Mg, K, Ca, and Ti as associated production connected with the production of Xe by the cold fissioning of Pt and Pd. Just as importantly, or perhaps even more so, is the model's support for the interesting abundance shifts among the respective stable isotopes of Xe, and of Mg, K, Ca, and Ti. These significant shifts away from the natural isotopic abundance percentages constitute strong evidence for a nuclear signature for the phenomenon producing these isotopes, as opposed to an origin via contamination.

It is important to note too that, should it be claimed that some artifact associated with the detection method vitiates the claim made for Mizuno's Xe result ([2], [3]), for example, it is extremely unlikely that his other results would likewise be vitiated. Thus, such good agreement between his results and the present model in essence mutually strengthens the claims of both. Additionally, G. Miley of the University of Illinois (Champagne-Urbana) has indicated (Miley and Patterson [4]) that his similar analysis of the nuclear reaction products for a CETI, Inc. Pd/Pt Patterson cell appears to mirror the findings of Mizuno. This, of course, considerably augments the credibility of the composite picture.

Table 1, entitled **Xe Isotopic Analysis**, shows that the model is normalized to Mizuno's data for Xe-129. Thus, by setting the model's percentage abundance of Xe-129 to the 18% found by Mizuno ([2], [3]), the model was then able to provide a theoretical prediction of the percentage abundances for all of the other stable isotopes of Xe based upon the cold fissioning of Pt plated over onto the Pd cathode and of the Pd itself. The bottom part of the table exhibits this. Thus, for the stable isotope Xe-132 the table indicates that its natural abundance is 26.89%, whereas Mizuno ([2], [3]) detected 18.5%. This represents a significant downward shift. The model yields a result of 16% for this same isotope. Thus, the factor X = 1.963 based upon normalizing to Mizuno's finding for Xe-129, gives a first result (column 4) based upon the hypothesized cold fissioning of the stable isotopes of Pt and Pd of 16.4%. When this latter value is corrected for the products of the cold fusioning of I-134 and I-129 the final result is 16%, in good agreement with Mizuno's result of 18.5%.

A comparison of columns 4 and 5 in Table 1 shows that the model gives a good agreement to the findings of Mizuno ([2], [3]). In addition the model gives values for four of the stable isotopes, Xe-130, 128, 126, 124, that are not given by Mizuno ([2], [3]). In going from the natural abundances to the theoretical abundances of the latter the natural values are predicted to shift by factors ranging from about 0.7, in the case of Xe-130, to about 35 for the case of Xe-124, which is predicted to shift in abundance from 0.096% to 3.4%.

Table 2 summarizes the production of Xe isotopes from the cold fissioning of the stable Pt isotopes. (The theoretical results in Table 1 are the result of adding to these results the Xe production resulting from the cold fissioning of Pd and the cold fusioning of I-134, 129 with a deuteron.)

Table 3 shows just one page of the very many pages employed by the author to obtain the results for Xe summarized in Table 2. To exemplify what is summarized in Table 3, consider the intersection of the third row from the bottom and the final column (eighth column): The interpretation is that one nucleus of Ca-43 is the result of the cold fissioning of Pt-198, which also yields one nucleus of Mg-24 and one nucleus of Xe-131. The full-fledged equation is as follows:

$$12\,({}_{-1}e^{0}) + \overset{0+}{{}_{78}Pt^{198}} \rightarrow \overset{3/2+}{{}_{54}Xe^{131}} + \overset{0+}{{}_{12}Mg^{24}} + \overset{7/2-}{{}_{20}Ca^{43}} + 20\,({}_{-1}e^{0}) + 8\,\tilde{\nu}_e$$

The Q-value is approximately 111 Mev, implying, by energy conservation, that about 111 Mev should be given off in this reaction. However, this energy would not be available as excess heat since. while some of the energy would go into the kinetic energy of the emerging electrons (betas) the vast preponderance of the energy would be carried away by the eight electron antineutrinos. (The eight antineutrinos are necessary to conserve "lepton number".) Note that parity is not conserved, since it is positive on the lefthand side and negative on the right. Thus, this is an example of a "weak" interaction, a group of interactions well known to not conserve parity.

Table 4 is just one example of the many pages employed by the author to summarize the cold fission reactions for Pd.

The top half of **Table 5** summarizes the results for the associated production of Ca isotopes (top) with Xe accompanying Pt cold fissioning, while the bottom half of Table 5 does the same for the associated production of K isotopes. **Table 6** does the same for the associated production of Mg isotopes (top) and for Ti isotopes (bottom). Note that, in all cases where Mizuno ([2], [3]) has stated a percentage abundance of an isotope that the model's prediction compares well. Additionally, the model makes a number of predictions for percentage abundances for isotopes for which Mizuno has not stated a finding. These isotope shifts are a dramatic signature that we are seeing an unfamiliar form of nuclear interaction.

Now, it should also be noted that the results from the cold fissioning of Pd have not been factored into the results shown for this associated production of isotopes (Tables 5, 6). Thus, since the model's results are in such good agreement with the isotope abundance shifts found by Mizuno ([2], [3]), there is the strong suggestion that the general trends produced via angular momentum (spin) and parity considerations inherent in the model for isotope production are a feature that we would expect to show up in different mass regions when the model is applied to those regions.

APPLICATION TO RADIATION REMEDIATION

The excellent agreement of this model with Mizuno's experimental results encourages its application to the phenomenon of "radiation remediation."

Table 7 is but one example of the many pages worked out by the author for the case of the cold fissioning of Thorium 232.

Table 8 is a similar example for Bismuth 212. The predominant reactions in all cases are cold fissionings. **However, one would not expect to observe excess heat in the lattice in these reactions since excess energy will be carried off by neutrinos.** (In the cases shown here the neutrinos are electron antineutrinos.) The fact that the laboratory of Morning Star, Inc., is still standing is attributed in the model to such neutrinos. Clearly it would be extremely interesting to put a cold fusion/fission cell in front of a detector for electron antineutrinos.

REFERENCES

1. R.T. Bush. "Some Theoretical Observations Upon Lattice-Assisted Nuclear Reactions in an Electrolytic Cell with Pd (Cathode) and Pt (Anode)," Presented for Dr. Bush at the Second Conference on Low Energy Nuclear Reactions (College Station Texas 9/14/96) b J. Dunn.
2. T. Mizuno, T. Ohmori, M. Enyo, "Anomalous Isotopic Distribution in Palladium Cathode after Electrolysis," *Infinite Energy Magazine,* March-April 1996 (#7), p. 10.

3. T. Mizuno, T. Ohmori, M. Enyo, "Isotopic Changes of the Reaction Products Induced by Cathodic Electrolysis in Pd," *Journal of New Energy,* vol 1, no. 3, 1996, p. 31.
4. G.H. Miley, J. Patterson, "Nuclear Transmutations in Thin-Film Nickel Coatings Undergoing Electrolysis," *Journal of New Energy,* vol 1, no. 3, 1996, p. 5.
5. R.T. Bush, "A Light Water Excess Heat Reaction Suggests That 'Cold Fusion' May be 'Alkali Fusion'," *Fusion Technol.,* 22, 301(1992).
6. R.T. Bush, "A Unifying Model for Cold Fusion," *Trans. of Fusion Technol.,* 26, No. 4T, Part 2, December 1994, pp. 431-441.
7. G.H. Miley, H. Hora, E. Batyrbekov, and R. Zich, "Electrolytic Cell with Multilayer Thin film Electrodes," *Trans. Fusion Technol.,* 26, No. 4T Part 2, December 1994, pp. 313-320.
8. S. Gleason, R. Neal, Morning Star, Inc. Cincinnati, Ohio, Private communications, Fall
9. R.T. Bush, "Cold Fusion / Cold Fission to Account for Radiation Remediation," *Infinite Energy Magazine,* 3, No. 13 & 14, 1997, p. 30.

Acknowledgment

It is a pleasure to express my appreciation to S. Gleason and R. Neal for allowing me to visit their laboratory in Cincinnati and to discuss aspects of their radiation remediation experiments with them in the Fall of 1996. Thanks also go to D. Holloman and V. Holloman for financing my visit. And while the theory presented here emerged in the late spring of 1996, I wish to thank Morning Star, Inc. of Cincinnati, Ohio, for funding release time for me to study this problem in the Winter of 1996. Finally, I wish to thank H. Fox, Editor, *Journal of New Energy* and E. Mallove, Editor, *Infinite Energy* Magazine, for their encouragement of my work.

A COMMENT by Dr. Jin

The paper proposed an "electron-induced fusion" and "electron-induced fission" model for the low-energy nuclear transmutations, and the model is employed to account for the phenomenon of "radiation remediation." As one of the models to explain the low-energy transmutation, it merits attention and reference.

According to current nuclear physics and particle physics, electrons belong to the *leptons* family, it may participate in gravitational, electromagnetic, and weak interactions; but electrons are not known to participate in strong interactions. It means that electrons may participate in β decay (β^- decay, β^+ decay, and electron capture) which are weak interactions, and screen the Coulomb barrier near nuclei, which is an electromagnetic interaction, but cannot directly induce reactions (strong interactions). Under these circumstances, how could an "electron-induced fusion" and "electron-induced fission" happen? How could, and through what way, can a nucleus be excited by electrons?

According to the author, "In **cold fission**, the number of electrons has been so increased over the cold fusion case that, at least charge-wise, some protons seem like neutrons." Certainly, electrons could screen the Coulomb field of nuclei, but electrons would not be expected to make "some protons seem like neutrons." A neutron and a proton screened by electrons are essentially different things.

The "lattice-assisted" nuclear process might be different with conventional nuclear processes. What is the mechanism of low-energy nuclear transmutation? More investigation is definitely needed. This paper is important to direct our thinking and our experiments to resolve these questions.
Dr. X.S. Jin 9/9/97

Table 1

Xe ISOTOPIC ANALYSIS

The normalization is to Mizuno's Experimentally Determined Shift in Isotopic Abundance for Xe^{129}:

Abundance for : Xe^{129}	26.44% (Natural)	18% (Mizuno)

[*Fig. in *Infinite Energy*, Mar-Apr 1996 (#7)]

	Natural Values	New Values
Xe^{136}	8.87%	8.87% + (7.6%) (X) ***
Xe^{134}	10.44%	10.44% + (8.1%) (X)
Xe^{132}	26.89%	26.89% + (11.1%) (X)
Xe^{131}	21.18%	21.18% + (12.5%) (X)
Xe^{130}	4.08%	4.08% + (10.7%) (X)
*Xe^{129}	26.44%	26.44% + (13.7%) (X)**
Xe^{128}	1.92%	1.92% + (9.4%) (X)
Xe^{126}	0.09%	0.09% + 11.6%) (X)
Xe^{124}	0.096%	0.096% + (15.2%) (X)
Sums:	[100%]	[100% + (100%) (X)]**

** Mizuno's result applied for Normalization
*** This Weighing Factor is the “% of total” taken from the Xenon Production Chart.

Normalization Equation:

$$\frac{26.44\% + 13.7\%}{[100\% \ (1 + X)]} \cdot 100 = 18\% \quad \text{Therefore, } X = 1.963 \,.$$

	Natural	**Mizuno**	**Theoretical Model** X = 1.963	**Model Renormalization** to account for the Fusion of $I^{134,\,129}$ to produce $Xe^{136,\,131}$
Xe^{129}	26.44%	18%	18%	18%
Xe^{136}	8.87%	25%	8%	21%
Xe^{134}	10.44%	12.5%	8.9%	11%
Xe^{132}	26.89%	18.5%	16.4%	16%
Xe^{131}	21.18%	28%	15.4%	23%
Xe^{130}	4.08%	(?)	8.5%	2.8%
Xe^{128}	1.92%	(?)	6.9%	2.3%
Xe^{126}	0.09%	(?)	7.7%	2.6%
Xe^{124}	0.096%	(?)	10.1%	3.4%

Table 2

PRODUCTION OF STABLE XENON ISOTOPES ASSOCIATED WITH THE LATTICE-ASSISTED FISSION OF PLATINUM

N = Relative Number of Reactions

WN = Weighted Number = (N) · (% Pt)

NA% → $_{54}$Xe →	8.87% 136	10.44% 134	26.89% 132	21.18% 131	4.08% 130	26.44% 129	1.92% 128	0.09% 126	0.096% 124
$_{78}$Pt									
0.0127% (0+) 190									
0.78% (0+) 192				1 0.78	2 1.56	3 2.34	3 3.24	5 3.9	5 3.9
32.9% (0+) 194			2 65.8	2 65.8	3 98.7	5 164.5	3 98.7	5 164.5	6 197.4
33.8% (1/2-) 195	N = 10 WN = 338	9 304.2	10 338	10 338	7 236.6	7 236.6	5 169	5 169	8 270.4
25.3% (0+) 196		2 50.6	3 75.9	5 126.5	5 126.5	7 177.1	5 126.5	6 151.8	7 177.1
7.21% (0+) 198	N = 2 WN =14.42	3 21.63	5 36.05	7 50.47	5 36.05	8 57.68	6 43.26	7 50.47	8 57.68
Weighted Totals % of total	352.42 7.6%	376.43 8.1%	515.75 11.1%	581.55 12.5%	499.41 10.7%	638.23 13.7%	439.82 9.4%	539.71 11.6%	706.54 15.2%

TABLE 3

		0.0127%	0.78%	32.9%	33.9%	25.3%	7.21%
$_{78}Pt$ →		(0+) 190	(0+) 192	(0+) 194	1/2- 195	(0+) 196	(0+) 198
0+ $_{12}Mg^{24}$	0+ $_{54}Xe^{134}$ 10.44%	–	–	–	3/2+ $_{17}Cl^{37}$ 24.47%	2– $_{17}Cl^{38}$ 37.24 m	4– $_{21}Sc^{40}$ 182 ms
	–	–	–	–	3/2+ $_{18}Ar^{37}$ 35.04 d	–	–
	–	–	–	–	3/2+ $_{19}K^{37}$ 1.23 s	–	–
	0+ $_{54}Xe^{136}$ 8.87%	–	–	–	3/2+ $_{16}S^{35}$ 87.5 d	–	2- $_{17}Cl^{38}$ 37.24 m
	–	–	–	–	3/2+ $_{17}Cl^{35}$ 75.53%	–	–
	–	–	–	–	3/2+ $_{a8}Ar^{35}$ 1.78 s	–	–
	0+ $_{54}Xe^{132}$ 26.89%	–	–	2- $_{17}Cl^{38}$ 37.2 m	3/2+ $_{17}Cl^{39}$ 55.6 m	4- $_{21}Sc^{40}$ 182 ms	2- $_{19}K^{42}$ 12.4 h
	–	–	–	–	3/2+ $_{19}K^{39}$ 93.10%	–	–
	–	–	–	–	3/2+ $_{20}Ca^{39}$ 860 ms	–	–
	3/2+ $_{54}Xe^{131}$ 21.18%	–	7/2- $_{16}S^{37}$ 5 m	7/2- $_{18}Ar^{39}$ 269 y	0+ $_{18}Ar^{40}$ 99.60%	7/2- $_{18}Ar^{41}$ 1.83 h	7/2- $_{20}Ca^{43}$ 0.145%
	–	–	–	–	0+ $_{19}K^{40}$ 0.0118%	7/2- $_{20}Ca^{41}$ 1.03×10^5 y	7/2- $_{21}Sc^{43}$ 3.9 h
	–	–	–	–	0+ $_{20}Ca^{40}$ 96.97 ms	7/2- $_{21}Sc^{41}$ 596 ms	7/2- $_{22}Ti^{43}$ 510 ms

TABLE 4

$_{46}Pd$ →		(0+) 110	(0+) 108	(0+) 106	5/2- 105	(0+) 104	(0+) 102
	7/2- $_{22}Ti^{43}$	–	–	–	–	–	–
	? $_{22}Ti^{41}$	–	–	–	–	–	–
	3/2- $_{22}Ti^{53}$	–	–	–	–	–	–
	7/2- $_{22}Ti^{51}$	0+ $_{12}Mg^{26}$	0+ $_{12}Mg^{24}$	–	–	–	–
	7/2- $_{22}Ti^{49}$	0+ $_{14}Si^{28}$	0+ $_{12}Mg^{26}$	–	–	–	–
	5/2- $_{22}Ti^{47}$	0+ $_{14}Si^{30}$	0+ $_{14}Si^{28}$	–	–	–	–
	7/2- $_{22}Ti^{45}$	0+ $_{14}Si^{32}$	0+ $_{14}Si^{30}$	–	–	–	–
	7/2- $_{22}Ti^{43}$	–	–	–	–	–	–
	? $_{22}Ti^{41}$	–	–	–	–	–	–
0+ $_{16}S^{32}$	3/2- $_{22}Ti^{53}$	–	–	–	–	–	–
	3/2- $_{22}Ti^{51}$	5/2+ $_{13}Al^{27}$	–	–	–	–	–
	7/2- $_{22}Ti^{49}$	1/2+ $_{14}Si^{29}$	5/2+ $_{13}Al^{27}$	–	–	–	–

TABLE 5

ASSOCIATED Ca PRODUCTION

(ISOTOPE)	(NATURAL)	(MIZUNO)	(THEORETICAL)
40*	96.97%	92%	92%
42	0.64%	?	1.9%
43	0.145%	?	2.25%
46	0.0033%	?	0.44%
48	0.18%	?	0.60%
44	2.06%	?	2.80%

*Normalization of the Theoretical results is to Mizuno's Result for Ca 40.

ASSOCIATED K PRODUCTION

(ISOTOPE)	(NATURAL)	(MIZUNO)	(THEORETICAL)
39*	93.10%	85%	85%
40	0.0118%	?	4.5%
41	6.88%	10.5%	10.5%

*Normalization of the Theoretical results is to Mizuno's Result for K 39.

TABLE 6

ASSOCIATED Mg PRODUCTION

(ISOTOPE)	(NATURAL)	(MIZUNO)	(THEORETICAL)
24*	78.7%	74%	74%
25	10.13%	11% - 12%	13.6%
26	11.17%	12.4%	12.4%

*Normalization of the Theoretical results is to Mizuno's Result for Mg 24.

ASSOCIATED Ti PRODUCTION

(ISOTOPE)	(NATURAL)	(MIZUNO)	(THEORETICAL)
48*	73.94%	60%	60%
46	7.93%	?	10.9%
47	7.28%	approx. 16%	16.2%
49	5.51%	?	8.9%
50	5.34%	?	4.0%

*Normalization of the Theoretical results is to Mizuno's Result for Ti 48.

TABLE 7

$\overset{0+}{{}_{90}\mathrm{Th}^{232}}$: (continued)

[13]

(82) $8\,({}_{-1}e^0) + \overset{0+}{{}_{44}\mathrm{Ru}^{106}} \rightarrow \overset{0+}{{}_{8}\mathrm{O}^{18}} + \overset{3/2-}{{}_{28}\mathrm{Ni}^{61}} + \overset{5/2-}{{}_{13}\mathrm{Al}^{27}} + 14\,({}_{-1}e^0) + 6\,\tilde{\nu}_e$

(83) $8\,({}_{-1}e^0) + \overset{0+}{{}_{44}\mathrm{Ru}^{106}} \rightarrow \overset{0+}{{}_{8}\mathrm{O}^{18}} + \overset{3/2-}{{}_{28}\mathrm{Ni}^{59}} + \overset{1/2-}{{}_{14}\mathrm{Si}^{29}} + 13\,({}_{-1}e^0) + 5\,\tilde{\nu}_e$

[12]

(1) $12\,({}_{-1}e^0) + \overset{0+}{{}_{90}\mathrm{Th}^{232}} \rightarrow \overset{5/2+}{{}_{66}\mathrm{Mg}^{25}} + \overset{0+}{{}_{66}\mathrm{Dy}^{164}} + \overset{7/2-}{{}_{20}\mathrm{Ca}^{43}} + 20\,({}_{-1}e^0) + 8\,\tilde{\nu}_e$

(2) $12\,({}_{-1}e^0) + \overset{0+}{{}_{90}\mathrm{Th}^{232}} \rightarrow \overset{5/2+}{{}_{12}\mathrm{Mg}^{25}} + \overset{5/2-}{{}_{66}\mathrm{Dy}^{163}} + \overset{0+}{{}_{20}\mathrm{Ca}^{44}} + 20\,({}_{-1}e^0) + 8\,\tilde{\nu}_e$

(3) $12\,({}_{-1}e^0) + \overset{0+}{{}_{90}\mathrm{Th}^{232}} \rightarrow \overset{5/2+}{{}_{12}\mathrm{Mg}^{25}} + \overset{0+}{{}_{66}\mathrm{Dy}^{162}} + \overset{7/2-}{{}_{21}\mathrm{Sc}^{45}} + 21\,({}_{-1}e^0) + 9\,\tilde{\nu}_e$

(4) $12\,({}_{-1}e^0) + \overset{0+}{{}_{90}\mathrm{Th}^{232}} \rightarrow \overset{5/2+}{{}_{12}\mathrm{Mg}^{25}} + \overset{0+}{{}_{66}\mathrm{Dy}^{160}} + \overset{5/2-}{{}_{22}\mathrm{Ti}^{47}} + 22\,({}_{-1}e^0) + 10\,\tilde{\nu}_e$

(5) $12\,({}_{-1}e^0) + \overset{0+}{{}_{90}\mathrm{Th}^{232}} \rightarrow \overset{5/2+}{{}_{12}\mathrm{Mg}^{25}} + \overset{0+}{{}_{66}\mathrm{Dy}^{158}} + \overset{7/2-}{{}_{22}\mathrm{Ti}^{49}} + 22\,({}_{-1}e^0) + 10\,\tilde{\nu}_e$

(6) $12\,({}_{-1}e^0) + \overset{0+}{{}_{90}\mathrm{Th}^{232}} \rightarrow \overset{5/2+}{{}_{12}\mathrm{Mg}^{25}} + \overset{0+}{{}_{66}\mathrm{Dy}^{156}} + \overset{7/2-}{{}_{23}\mathrm{V}^{51}} + 23\,({}_{-1}e^0) + 11\,\tilde{\nu}_e$

(7) $12\,({}_{-1}e^0) + \overset{0+}{{}_{90}\mathrm{Th}^{232}} \rightarrow \overset{0+}{{}_{12}\mathrm{Mg}^{24}} + \overset{5/2+}{{}_{66}\mathrm{Dy}^{161}} + \overset{7/2-}{{}_{22}\mathrm{Ti}^{47}} + 22\,({}_{-1}e^0) + 10\,\tilde{\nu}_e$

(8) $12\,({}_{-1}e^0) + \overset{0+}{{}_{90}\mathrm{Th}^{232}} \rightarrow \overset{0+}{{}_{12}\mathrm{Mg}^{26}} + \overset{0+}{{}_{66}\mathrm{Dy}^{160}} + \overset{9/2-}{{}_{21}\mathrm{Sc}^{45}} + 21\,({}_{-1}e^0) + 9\,\tilde{\nu}_e$

(9) $12\,({}_{-1}e^0) + \overset{0+}{{}_{90}\mathrm{Th}^{232}} \rightarrow \overset{5/2+}{{}_{12}\mathrm{Mg}^{25}} + \overset{0+}{{}_{66}\mathrm{Dy}^{158}} + \overset{7/2-}{{}_{23}\mathrm{V}^{51}} + 23\,({}_{-1}e^0) + 10\,\tilde{\nu}_e$

(10) $12\,({}_{-1}e^0) + \overset{0+}{{}_{90}\mathrm{Th}^{232}} \rightarrow \overset{0+}{{}_{12}\mathrm{Mg}^{26}} + \overset{0+}{{}_{66}\mathrm{Dy}^{156}} + \overset{7/2-}{{}_{22}\mathrm{Ti}^{49}} + 22\,({}_{-1}e^0) + 10\,\tilde{\nu}_e$

e.g. Dy

(11) $12\,({}_{-1}e^0) + \overset{0+}{{}_{66}\mathrm{Dy}^{164}} \rightarrow \overset{0+}{{}_{12}\mathrm{Mg}^{26}} + \overset{5/2+}{{}_{42}\mathrm{Mo}^{97}} + \overset{7/2-}{{}_{20}\mathrm{Ca}^{41}} + 20\,({}_{-1}e^0) + 8\,\tilde{\nu}_e$

(12) $12\,({}_{-1}e^0) + \overset{0+}{{}_{66}\mathrm{Dy}^{164}} \rightarrow \overset{0+}{{}_{12}\mathrm{Mg}^{26}} + \overset{5/2+}{{}_{42}\mathrm{Mo}^{95}} + \overset{7/2-}{{}_{20}\mathrm{Ca}^{43}} + 20\,({}_{-1}e^0) + 8\,\tilde{\nu}_e$

(13) $12\,({}_{-1}e^0) + \overset{0+}{{}_{66}\mathrm{Dy}^{164}} \rightarrow \overset{0+}{{}_{12}\mathrm{Mg}^{26}} + \overset{5/2+}{{}_{42}\mathrm{Mo}^{93}} + \overset{7/2-}{{}_{21}\mathrm{Sc}^{45}} + 21\,({}_{-1}e^0) + 9\,\tilde{\nu}_e$

TABEL 8

$\tilde{\nu}_e$ = antielectron neutrino

$\overset{1-}{{}_{83}\mathrm{Bi}^{212}}$

14: $14\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{0+}{{}_{14}\mathrm{Si}^{28}} + \overset{1+}{{}_{55}\mathrm{Cs}^{130}} + \overset{0+}{{}_{24}\mathrm{Cr}^{54}} + 24\,({}_{-1}e^0) + 10\,\tilde{\nu}_e +$ (157.1505 MeV)

13: $13\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{5/2+}{{}_{13}\mathrm{Al}^{27}} + \overset{7/2+}{{}_{57}\mathrm{La}^{139}} + \overset{0+}{{}_{22}\mathrm{Ti}^{46}} + 22\,({}_{-1}e^0) + 9\,\tilde{\nu}_e +$ (140.413 MeV)

12: $12\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{0+}{{}_{12}\mathrm{Mg}^{24}} + \overset{7/2+}{{}_{59}\mathrm{Pr}^{138}} + \overset{0+}{{}_{22}\mathrm{Ti}^{50}} + 22\,({}_{-1}e^0) + 10\,\tilde{\nu}_e +$ (140.3557 MeV)

11: $11\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{3/2+}{{}_{11}\mathrm{Na}^{23}} + \overset{5/2+}{{}_{61}\mathrm{Pm}^{145}} + \overset{0+}{{}_{20}\mathrm{Ca}^{44}} + 20\,({}_{-1}e^0) + 9\,\tilde{\nu}_e +$ (124.1306 MeV)

10: $10\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{0+}{{}_{10}\mathrm{Ne}^{20}} + \overset{5/2+}{{}_{63}\mathrm{Eu}^{153}} + \overset{3/2+}{{}_{19}\mathrm{K}^{39}} + 19\,({}_{-1}e^0) + 9\,\tilde{\nu}_e +$ (107.1692 MeV)

9: $9\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{1/2+}{{}_{9}\mathrm{F}^{19}} + \overset{3/2+}{{}_{65}\mathrm{Tb}^{159}} + \overset{0+}{{}_{16}\mathrm{S}^{34}} + 16\,({}_{-1}e^0) + 7\,\tilde{\nu}_e +$ (92.8196 MeV)

8: $8\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{0+}{{}_{8}\mathrm{O}^{16}} + \overset{1+}{{}_{67}\mathrm{Ho}^{162}} + \overset{0+}{{}_{14}\mathrm{S}^{34}} + 16\,({}_{-1}e^0) + 8\,\tilde{\nu}_e +$ (92.5802 MeV)

7: $7\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{1+}{{}_{7}\mathrm{N}^{14}} + \overset{1/2+}{{}_{69}\mathrm{Tm}^{169}} + \overset{1/2+}{{}_{14}\mathrm{Si}^{29}} + 14\,({}_{-1}e^0) + 7\,\tilde{\nu}_e +$ (72.1643 MeV)

6: $6\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{0+}{{}_{6}\mathrm{C}^{12}} + \overset{7/2+}{{}_{71}\mathrm{Lu}^{175}} + \overset{5/2+}{{}_{12}\mathrm{Mg}^{25}} + 12\,({}_{-1}e^0) + 6\,\tilde{\nu}_e +$ (60.2148 MeV)

5: $5\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{3/2+}{{}_{5}\mathrm{B}^{11}} + \overset{3-}{{}_{73}\mathrm{Ta}^{182}} + \overset{1/2+}{{}_{9}\mathrm{F}^{19}} + 9\,({}_{-1}e^0) + 4\,\tilde{\nu}_e +$ (31.1015 MeV)

4: $4\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{3/2+}{{}_{4}\mathrm{Be}^{9}} + \overset{1-}{{}_{75}\mathrm{Re}^{186}} + \overset{1/2+}{{}_{8}\mathrm{O}^{17}} + 8\,({}_{-1}e^0) + 4\,\tilde{\nu}_e +$ (23.2369 MeV)

3: $3\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{1+}{{}_{3}\mathrm{Li}^{6}} + \overset{3/2+}{{}_{77}\mathrm{Ir}^{189}} + \overset{3/2+}{{}_{11}\mathrm{Na}^{23}} + 11\,({}_{-1}e^0) + 4\,\tilde{\nu}_e +$ (25.7873 MeV)

2: $2\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow \overset{1/2+}{{}_{2}\mathrm{He}^{3}} + \overset{3/2+}{{}_{79}\mathrm{Au}^{197}} + \overset{0+}{{}_{6}\mathrm{C}^{12}} + 6\,({}_{-1}e^0) + 4\,\tilde{\nu}_e +$ (8.0837 MeV)

*1: $1\,({}_{-1}e^0) + \overset{1-}{{}_{83}\mathrm{Bi}^{212}} \rightarrow {}_{1}\mathrm{H}^{1} + \overset{1/2+}{{}_{81}\mathrm{Tl}^{205}} + \overset{1+}{{}_{3}\mathrm{Li}^{6}} + 3\,({}_{-1}e^0) + 2\,\tilde{\nu}_e +$ (-6.5167 MeV)

* Impossible cold reaction due to large negative Q value.

THE TNCF MODEL – A PHENOMENOLOGICAL MODEL FOR THE COLD FUSION PHENOMENON

Hideo Kozima [1]

ABSTRACT

Basic concepts of the Trapped Neutron Cold Fusion (TNCF) model for cold fusion are presented with some examples of analysis of typical experimental data on the excess heat, tritium and helium generation and the nuclear transmutation in cold fusion phenomena. The nature of the model is illustrated in connection with other famous models in physics. Fundamental assumptions in the TNCF model, trapping of thermal neutrons in the solid and its stabilization by the interaction with lattice nuclei, are contemplated briefly in terms of conventional physics.

INTRODUCTION

The TNCF model was proposed three years ago [1] to interpret the confusing experimental data in cold fusion phenomena. After declaration of its discovery [2], world-wide controversy burst into flames around cold fusion with scandalous disclosures of nonscientific affairs. Fundamental causes of the controversy were the conceptual barrier for the new phenomenon and secrecy about the patent barrier. As a matter of science, the former is more important, which dogmatically assumed that cold fusion in materials with hydrogen isotopes at room temperature should be induced by the same nuclear reactions just as those at high energy in vacuum. Many physicists denied experimental data which were characterized by low reproducibility and by apparent inconsistencies in observed events when interpreted using conventional views of particle physics.

It is instructive to recollect typical models in the history of science which at first seemed ridiculous even though they could explain new experimental results which contradicted with old concepts. We consider two typical examples, the Bohr model for hydrogen atom and the two-fluid model of the superfluidity in liquid helium. The Bohr model could explain the atomic spectra of hydrogen and finite size of it on the assumption that there are stationary electron orbits even though these orbits contradicted classical electrodynamics. Later, these assumptions were systematized as Quantum Mechanics, which is entirely different from classical physics.

The two-fluid model was proposed to explain the experimental data of superfluidity in liquid helium. This model assumes a new concept of super-fluid which has no viscosity at all. This new concept contradicts the old concept of classical fluid but is able to explain the experimental data and predicts the existence of the second fluid state which was discovered later experimentally.

Thus, a good model is very effective if it can systematically account for perplexing experimental data even if its basis is ambiguous for a while. The TNCF model is a phenomenological one which tries to explain complex experimental data in the cold fusion phenomenon. A majority of scientists, especially physicists, who have not thoroughly investigated the matter, are presently skeptical towards cold fusion.

[1] Dept. of Physics, Faculty of Science, Shizuoka University, 836 Oya, Shizuoka 422, Japan.
Fax +81-54-238-0993, E-mail: sphkoji@sci.shizuoka.ac.jp

Characteristics of the TNCF Model and Explanation of Some Typical Experimental Data

The TNCF model has been applied to analyze more than forty sets of data from experiments until now obtained in various circumstances and materials. The results were published also in compiled forms [3~6]. The fundamental assumptions of the TNCF model, similar in its nature to the stationary electron orbits in Bohr's model of hydrogen atom and the superfluid in the two-fluid model of liquid helium, are existence of quasi-stable neutrons in cold fusion materials and their selective reaction with some nuclei.

In the model, there is one adjustable parameter n_n, the density of the trapped thermal neutron, which is used to analyze the cold fusion phenomenon with several events specified by some physical quantities supposed to be results of various physical processes in the material. Some examples of these quantities are: 1) gamma ray spectra, neutron energy spectra and distribution of transmuted nuclei in the material and 2) the excess heat, amounts of generated tritium and helium in a definite time, X ray and other charged particles if any. The quantities in group 1) are direct evidences having direct information of the events and those in group 2) indirect.

There are some premises [4~6] which connect n_n and the observed quantities which are summarized as follows: The quasi-stable trapped neutron is stable against the destined beta disintegration in its free state and also against fusion with one of nuclei on the lattice points (lattice nuclei). The neutron in a material can fuse with a nucleus, for instance, in the surface layer which reflects the neutron back into the material in a classical sense. The fusion cross section in this case is assumed to be the same as that in vacuum.

With these assumptions, more than forty typical experimental facts including those by Fleischmann et al. [2], Morrey et al. [7], Miles et al. [8], Storms et al. [9], Gozzi et al. [10] and Bush et al [11] were analyzed successfully with consistent results. The results [12~15] are summarized as follows: In the pioneering work [2] where excess heat is observed, tritium and neutrons in the electrolytic system with Pd cathode in D_2O + LiOD electrolytic solution (Pd/D/Li system), the controversial relations between these quantities were interpreted by our model [12] consistently with values of $n_n = 10^7 \sim 10^9$ cm^{-3} if we permit inconsistency in the experimental results which showed lack of expected simultaneity of events from the model.

The difficulty to explain production of ^{4}He in the electrolytic system of Pd/D/Li [2, 7, 8] were resolved by the reaction between the trapped neutron and ^{6}Li

$$n + 6\ \mathrm{Li} = {}^4\mathrm{He} + t, \qquad (1)$$

occurring in the surface layer of Li metal (and/or $PdLi_x$ alloy) on the cathode. The parameter n_n was determined [12] from the data in these experiments as $10^8 \sim 10^{10}$ cm^{-3}.

In the experiment [9] where excess heat and tritium is observed in Pd/D/Li system but without expected simultaneity, the parameter n_n was determined [13] as $10^7 \sim 10^{11}$ cm^{-3} with the same reservation for the simultaneity of events. The experiment [10] where excess heat, tritium and ^{4}He were observed in Pd/D/Li system, the data were interpreted [14] with $n_n = 10^{10} \sim 10^{11}$ cm^{-3} consistently altogether but again with the same reservation for the expected simultaneity of events. In the experiment [11] with Ni cathode and H_2O + Rb_2CO_3 electrolytic solution, the excess heat and a nuclear transmutation from ^{85}Rb to ^{86}Sr were observed. The result was explained consistently by the TNCF model [15] with $n_n = 1.4 \times 10^7$ cm^{-3}.

Thus, it is possible to interpret various, sometimes more than two events in the cold fusion phenomenon consistently assuming only one adjustable parameter n_n with a reservation of inexplicable problem of poor reproducibility and lack of simultaneity of events. To understand these unexplained points more clearly, it will be necessary to take details of the object materials into the TNCF model.

Physical Basis of Premises in the TNCF Model

The fundamental assumptions of the quasi-stable existence of the trapped neutron has been supported by the success in the explanation of the experimental data impossible to understand in the frame of conventional physics. The success itself shows previously the reality of the assumed quasi-stable neutrons trapped in materials which cause the cold fusion phenomenon. It is, however, desirable to investigate the quasi-stable neutron theoretically to develop physical understanding of the cold fusion phenomenon and to predict new effects expected from its nature if possible which will enable one to construct new physics -the solid state - nuclear physics. Several key problems about presumptions in the TNCF model are contemplated in this section.

First of all, it is questioned where the trapped neutron comes from. A probable primary source may be the environmental neutron which is very popular on the earth produced by cosmic ray in upper air at high altitude. The environmental neutron causes troublesome background for the measurement and make the neutron observation ambiguous, as we know well. There are evidences that the cold fusion phenomenon has not been observed in low background environment. Another evidence of the above interpretation of the source of the trapped neutron is the aging effect and the long pre-run effect for realization of the cold fusion phenomenon. These effects could be considered as results of a process for accumulation of a necessary amount of the trapped neutrons in materials from environment. After the piling up of minimum amount of the trapped neutron, the trigger reactions [3~5] such as the reaction (1) will feed a sufficient number of neutrons to the material.

Second question for the TNCF model is the mechanism of neutron trapping in materials. We have proposed several mechanisms for it. The most effective and realistic one based on present knowledge of the situation where cold fusion is the band structure effect [4,16]: difference of neutron bands in adjacent materials makes the trapped neutron impossible to pass though the boundary between them if an allowed band in one and a forbidden band in another coexist at the same energy.

Third question is the quasi-stability of the trapped neutron keeping it from beta decay and also from fusing with lattice nuclei in the material. To understand this concept, it is helpful to remember stability of a neutron in a nucleus, e.g. in a deuteron. The neutron in the deuteron is stable in the same meaning as above due to nuclear interaction with a proton in it. Similarly, a neutron trapped in a material as a Bloch wave could be stable due to the nuclear interaction with lattice nuclei. To investigate experimental data from our point of view, a new concept "neutron affinity" of a material was proposed [16,17] which has positive correlation with experimental data.

It is taken as a matter of course *that* these ideas introduced to explain possible existence of the quasi-stable trapped neutron in an appropriate material with some characteristics (which are manifested experimentally) should be verified experimentally by observations of the predicted phenomena by the model [18].

Recently, it is remarked that reduction of radioactivity of some radioactive nuclei, e.g. Th, occurs in the electrolytic system for the cold fusion experiment [19]. Though the details of these effects have not been described in published papers, it is possible to contemplate possible causes of the effect assuming its reality: The ion of a radioactive element dissolved into electrolytic solution will deposit on the cathode in the process of electrolysis just as the ion of the alkali metal in electrolyte (as Li^+, K^+ and so on) which is a key element in the electrolytic experiment from our point of view. The radioactive ion on or in the surface layer interacts with the trapped neutron to fuse with it resulting in some reactions; stabilization of the nucleus with emission of soft gamma ray or nuclear transmutation by emission of particle(s). The reduction of radioactivity could be interpreted by the TNCF model as above.

To clarify these possibilities, it is desirable to check the nature of the reduction of radioactivity scientifically: whether it is only the result of deposition of radioactive element on the cathode or is the result confirmed by the sum of whole element in the system, whether the reduction occurs on the cathode and then flow out into the solution or in the solution, and so on.

Conclusion

The cold fusion phenomenon consisting of generation of the excess heat, tritium, helium, gamma ray, neutron, transmuted nuclei in materials at near room temperature is very complex with its poor reproducibility, sporadic nature of events, inconsistency of the observed events with prediction, variety of materials showing it, and so forth. To investigate such a complex phenomenon experimentally and theoretically, it is desirable to have a solid stand point, if any, as a first small hold from which further development can be started.

A new phenomenon as a rule demands a new point of view. We have many historical examples which have been described in the first section of this paper, by Bohr's model of the hydrogen atom and the two-fluid model of superfluidity. We have to find out a missing factor [20] not noticed until now to explain new phenomenon known as the cold fusion phenomenon (it is tolerable to use this word so popular now until we determine the nature of the phenomenon clearly because we do not know at all about it).

There are several successful applications of the cold fusion phenomenon to generate the excess heat [21, 22], to reduce radioactivity [19] and so on. Technology is usually developed first, then science follows it, as history shows by a typical example – the steam engine: the invention of the modern condensing steam engine patented in 1769 by J. Watt preceded the discovery by N.L.S. Carnot in 1824 and its proof by R.J.E. Clausius in 1850 of the Carnot's theorem by more than a half century. If scientists remain indifferent to a new phenomenon with complex events difficult to understand from conventional concepts, the associated new technology will be used in society after a series of trial-and-error processes. To shorten the path to commercialize a new technology necessary for the present world, we have to be sensitive to a new possibility not only for application but also for the development of a new science which is reasonable and which may lead to the development of a new industry.

REFERENCES

1. H. Kozima, "Trapped Neutron Catalyzed Fusion of Deuterons and Protons in Inhomogencous Solids," *Trans. Fusion Technol. (Proc. ICCF4)* (1994), vol 26, p 508.
2. M. Fleischmann, S. Pons and M. Hawkins, "Electrochemically Induced Nuclear Fusion of Deuterium," *J. Electroanal. Chem.* (1989), vol 261, p 301.
3. H. Kozima, "Cold Fusion Phenomenon on the TNCF Model," Proc. 4th Russian Conf. on Cold Fusion and Nuclear Transmutation (May 1996, Sochi, Russia) (to be published); *Cold Fusion* , vol 20, p 31 (1996).
4. H. Kozima, "The TNCF Model - Its Fundamentals," *Cold Fusion* , vol 21, p 19 (1997).
5. H. Kozima, K. Khaki and M. Ohta, "The Physics of the Cold Fusion Phenomenon,"*Cold Fusion*, vol 22, p 58 (1997).

6. H. Kozima, K. Khaki and M. Ohta, "Anomalous Phenomenon in Solids Described by the TNCF Model," *Fusion Technology* (1997) (to be published).
7. J.R. Morrey, M.R. Caffee, H. Farfar, IV, N.J. Hoffman, G.B. Hudson, R.H. Jones, M.D. Kurz, J. Lupron, B.M. Oliver, B.V. Ruiz, J.F. Wacker and A. Van, "Measurements of Helium in Electrolyzed Palladium," *Fusion Technol.*, vol 18, p 659 (1990).
8. M.H. Miles, R.A. Hollins, B.F. Bush and J.J. Lagowski, "Correlation of Excess Power and Helium Production During D_2O and H_2O Electrolysis Using Palladium Cathodes," *J. Electroanal. Chem.*, vol 346, p 99 (1993).
9 E. Storms and C. Talcott, "Electrolytic Tritium Production," *Fusion Technol.*, vol 18, p 680 (1990); Storms, "Some Characteristics of Heat Production using the 'Cold Fusion' Effect," *Trans. Fusion Technol. (Proc. ICCF4)*, vol 26, p 96 (1994).
10. D. Gozzi, R. Caputo, P.L. Cignini, M. Tomcllini, G. Gigli, G. Balducci, E. Cisbani, S. Frullani, F. Garibaldi, M. Jodice and G.M. Urciuoli, "Calorimetry and Nuclear Byproduct Measurements in Electrochemical Confinement of Deuterium in Palladium," *J. Electroanal. Chem.*, vol 380, p 91 (1995); "Quantitative Measurements of Helium-4 in Gas Phase of Pd + D_2O Electrolysis" *ibid.*, p 109 (1995).
11. R. Bush and R. Eagleton, "Evidence for Electrolytically Induced Transmutation and Radioactivity Correlated with Excess Heat in Electrolytic Cells with Light Water Rubidium Salt Electrolytes," *Trans. Fusion Technol. (Proc. ICCF4)*, vol 26, p 344 (1994).
12. H. Kozima, S. Watanabe, K. Hiroe, M. Nomura, M. Ohta and K. Khaki, "Analysis of Cold Fusion Experiments Generating Excess Heat, Tritium and Helium," *J. Electroanal. Chem.*, vol 425, p 173 (1997).
13. H. Kozima, K. Yoshimoto, M. Ohta and K. Khaki, "TNCF Analysis of Tritium and Excess Heat Generations in Pd/D/Li System," *Cold Fusion* (to be published).
14. H. Kozima, M. Ohta and K. Khaki, "TNCF Analysis of Excess Heat, Tritium and Helium-4 Generation in Pd/D/Li System," *J. Electroanal. Chem.* (submitted).
15. H. Kozima, K. Hiroe, M. Nomura and M. Ohta, "On the Elemental Transmutation in Biological and Chemical Systems," *Cold Fusion*, vol 16, p 30 (1996).
16. H. Kozima, "Neutron Band, Neutron Cooper Pair and Neutron Life Time in Solid," *Cold Fusion*,, vol 16, p 4 (1996); Proc. 3rd Russian Conf. on Cold Fusion and Nuclear Transmutation (RCCFNTJ) (Oct 1995, Sochi, Russia), p 224 (1996).
17. H. Kozima, "Behavior of Neutrons in Crystals," *Cold Fusion*, vol 18, p 17 (1996).
18. H. Kozima, "Cold Fusion Phenomenon on the TNCF Model," Proc. 4th Russian Conf. on Cold Fusion and Nuclear Transmutation (May 1996, Sochi, Russia) (to be published); *Cold Fusion*, vol 20, p 31 (1996).
19. J. Patterson, private communication and TV report (ABC News, June 11, 1997).
20. H. Kozima, "Report of RCCFNT3," *Cold Fusion*, vol 15, p 18 (1996); Proc. RCCFNT3, p 11 (1996).
21. J.A. Patterson, US Patent #5,607,563.
22. J.M. Niedra, I.T. Myers, G.C. Fralick and P.S. Baldwin, "Replication of the Apparent Excess Heat Effect in a H_2O - K_2CO_3 - Ni Electrolytic Cell," *NASA Technical Memorandum 107167* (February, 1996).

NUCLEAR TRANSMUTATION IN A GAS-LOADING H/PD SYSTEM

Guang S. Qiao, Xiu M. Han,[1]
Ling C. Kong [2], Xing Z. Li [3]

ABSTRACT

Electron probe is used to detect the zinc component in the palladium wire which has been loaded with hydrogen in a gas-loading system for one year. The energy dispersive spectroscopy shows clearly that the Zn component increases by a factor of 160 in comparison with the original palladium wire, and the wave-length dispersive mode scanning shows that Zn spreads over the whole cross-section of the reacted palladium wire. This eliminates the possibility of Zn contamination from the environment, and provides a primary evidence of nuclear transmutation in the gas-loading H/Pd system.

INTRODUCTION

Excess heat measurement in the gas-loading D/Pd system has been pursued since 1995 [l]. The twin gas-loading systems were built in order to compare their difference in calorimetric features while deuterium gas and hydrogen gas were filled into the otherwise identical palladium wires. It was found that the temperature of the D/Pd system was always a little higher than that of the H/Pd system. The highest difference was 8°C, which corresponded to an excess heat on the order of 2 W per cm^3 of palladium in the D/Pd system. In those experiments, the H/Pd system was simply used as a control only. During the ICCF-6, G.H. Miley and J.A. Patterson published their nuclear transmutation results with a Patterson Power Cell [2] using light water only. There it was found that the nuclear transmutation happened even if the excess heat was not evident. An interesting idea came immediately that we should examine the element composition in our gas-loading systems also. Particularly, we should check if the H/Pd system manifests some feature of nuclear transmutation as well. The preliminary measurements show clear evidence that nuclear transmutation happened in the gas-loading H/Pd system as well.

EXPERIMENTAL APPARATUS

The apparatus has been described in Ref. [1] in detail. The vacuum annealed palladium wire (900°C in 10^{-3} Pa for 3 hours) was sealed in a stainless steel dewar. Hydrogen gas was loaded into the palladium wire in the gas phase instead of the electrolysis system (Fig. 1). Having been accompanied by a piece of incandescent tungsten filament in the dewar, the hydrogen gas is able to enter the palladium wire at a pressure of less than one atm. After one year of loading and de-loading,

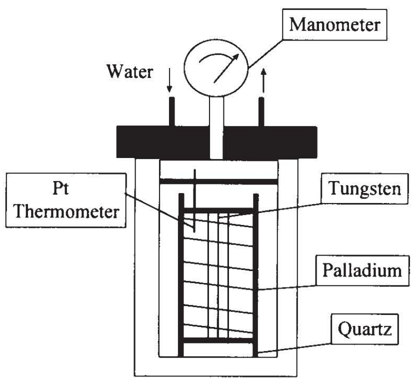


Fig. 1
The Gas-Loading System for H/Pd.

[1] Institute of Geology, Chinese Academy of Science, Beijing 100029, China

[2] Institute of Geology, State Seismological Bureau, Beijing 100029, China

[3] Department of Physics, Tsinghua Univ. Beijing 100084, China. Author to whom communication should be addrressed.
E-mail: lxz-dmp@mail.tsinghua.edu.cn

the resistance of the palladium wire increased to 5.5 ohms (the initial resistance was 2.7 ohms, the maximum resistance during the year was 5.5 ohms, and the terminal resistance after de-gasing was 3.0 ohms) which means that the atomic loading ratio, H/Pd, should be close to 0.74.

Zn IN THE PALLADIUM WIRE

A *CAMEBAX SX50* electron probe (WDS) and a *LINK isis* energy dispersive spectrometer (EDS) are used for the analysis of the element composition of the palladium wires. EDS is able to identify all the elements in the sample ranging from sodium to uranium. It is easy to identify any trace of an element of which concentration is higher than 0.1%. EDS was used first to identify qualitatively the elements which appeared at the footprint of the electron beam on the sample surface.

Fig.2(a) shows that the main ingredient of the original palladium wire is palladium, and Fig.2(b) shows that, after hydrogen-loading for one year in the palladium wire, Zn peaks are evident in addition to Pd peak, besides a weak Pb peak appearing as well. Hence, WDS quantitative analysis is applied to quantify the atomic concentration of each element involved. Table 1 shows the element composition of the original palladium wire. Six elements (Pd, Zn, Pb, Fe, Cu, and Sr) were checked. The size of the electron beam footprint was about 2 microns. Three points in the cross-section of a palladium wire (ϕ 0.34 mm) were examined. One point was at the center of the cross-section, and the other two were on the rim of the cross-section. The accelerative voltage is 15 kV. The current of the electron beam was 20 na., and the collection time was 50 seconds. The data are listed in three columns, respectively. It is evident that the original palladium is pure with impurities less than 0.6%. This is consistent with the manufacturer's specification.

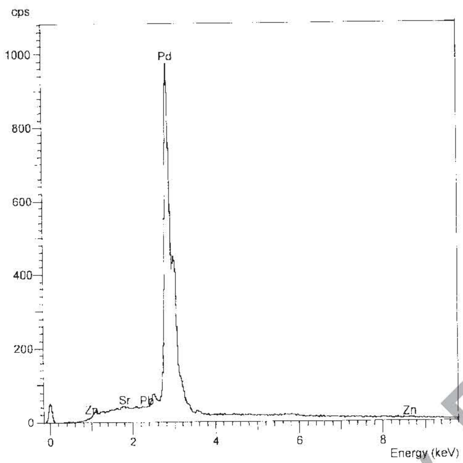


Fig. 2(a)

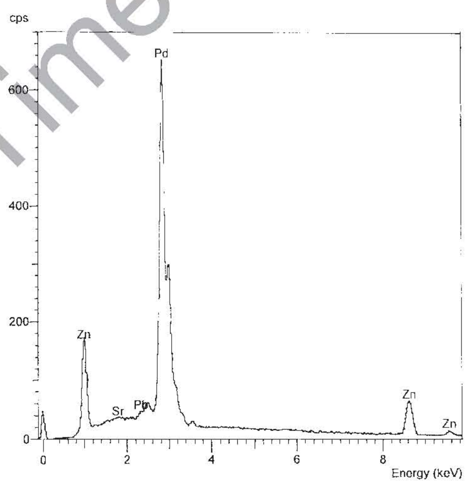


Fig. 2(b)

Table 1. Element Composition of Original Palladium

	Atomic Concentration (%)		
Elements	Rim 1	Rim 2	Center
Pd	99.61	99.58	99.44
Zn	0.22	0.23	0.24
Pb	0.07	0.00	0.08
Fe	0.01	0.19	0.18
Cu	0.09	0.00	0.07
Sr	0.00	0.00	0.00

The palladium wire after one year in the dewar filled with hydrogen gas was examined using same method in a cross-section of the palladium wire as well. Six points in the cross section were examined. Table 2 lists the result of examination. The Zn component appeared evidently again, particularly, in the surface layer. Fig. 3 shows the position of these six points schematically. The point 4 is inside the surface with a distance of 40 microns to the surface of palladium wire (the size in Fig. 3 is not proportional to the real scale). The points 5 and 6 are at the central area.

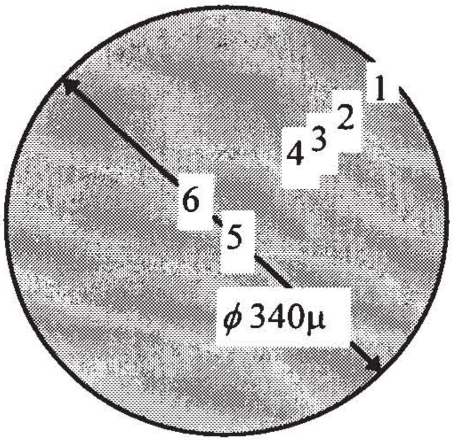


Fig. 3 Wire cross-section.

In addition, six points on the surface of the reacted palladium wire were examined along the length of the wire (in a range of 3.3 mm). The Zn component was evident in all six points. These data are listed in Table 3. (Electron beam current was 40 na., and the collection time was 50 seconds.)

The electron beam footprint is very small. It detects the micro range element composition only; therefore, it may fluctuate with the position of the electron beam. In order to obtain the general picture of the distribution of the Zinc component, the scanning feature of the electron probe was applied. The electron probe could scan the whole cross-section of the palladium wire point by point to show the distribution of the Zinc composition. When the electron beam scans through the cross-section of the palladium wire using a certain multiplication factor, the X-rays emitted by

Table 2. Element Composition of Reacted Palladium (cross section)

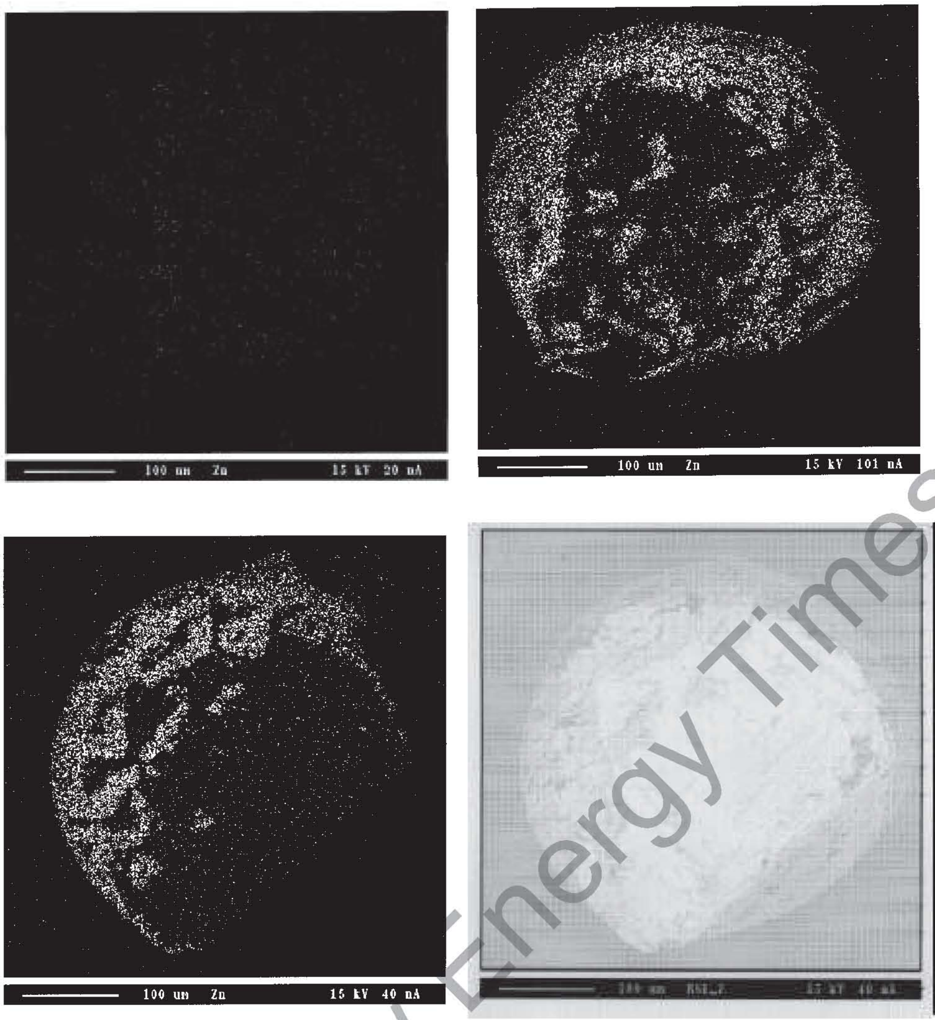
	Atomic Concentration (%)					
Element	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Pd	57.66	58.24	58.62	59.38	99.14	98.96
Zn	41.40	40.84	40.49	39.85	0.42	0.71
Pb	0.82	0.90	0.83	0.75	0.12	0.05
Fe	0.06	0.03	0.07	0.02	0.16	0.19
Cu	0.04	0.00	0.00	0.00	0.08	0.09
Sr	0.00	0.00	0.00	0.00	0.08	0.00

Table 3. Element Composition of Reacted Palladium Surface (along the length)

	Atomic Concentration (%)					
Elements	surface 1	surface 2	surface 3	surface 4	surface 5	surface 6
Pd	57.91	58.30	55.40	53.92	55.42	53.51
Zn	41.18	40.76	44.08	45.53	43.91	46.03
Pb	0.91	0.94	0.52	0.56	0.67	0.46
Sr	0.00	0.00	0.00	0.00	0.00	0.00

every point will reveal the local element composition at each point. The size of each point may be as small as several microns. Moreover, the spectrometer of the electron probe may be fixed to detect the certain wave length only. For example, we may collect the K_α characteristic X-ray of Zn only; then, the distribution of the K_α characteristic X-ray in the cross-section is obtained, which represents the image of the Zn distribution across the whole cross section.

Fig. 4 shows the image of the original palladium wire using WDS mode. The scintillant points are the background image caused mainly by bremsstrahlung. Fig. 5 is the image of the reacted palladium wire using WDS mode. The Milky-Way-like image of the Zn emission forms a ring around the circumference of the reacted palladium wire. Fig. 6 shows the Zn image across another cross-section of the reacted palladium wire.



Figs. 4 | 5
6 | 7
Fig. 4 Original Pd
Fig. 5 Reacted Pd
Fig. 6 Reacted Pd
Fig. 7 Background scattering electron image.

Additional evidence is obtained using the back-scattering electron (BSE) image of the same cross-section. Since the intensity of the back-scattering electron is proportional to the local average atomic number, and the atomic number for Zinc is 30 (which is clearly different from that of palladium, Z = 46), it is expected that the intensity of the back-scattering electrons should be much less around the circumference of the cross section in the reacted palladium wire. Fig. 7 shows the back scattering electron image for the same cross-section of the palladium wire in Fig. 6. The lower-right corner of Fig. 7 has a gray area which was caused by the uneven surface generated in the cutting procedure.

DISCUSSION

The zinc component was less than 0.25% in the original palladium wire, and it increases to more than 40%. Such a big change cannot be caused by any contamination, because the Zn component appears not only in the surface layer with a thickness of 40 microns, but also appears inside the palladium wire according to the K_α characteristic X-ray image of Zn (see Fig. 5 and Fig. 6). It provides the first strong evidence of nuclear transmutation in the gas loading H/Pd system.

We are particularly interested in the gas-loading system, because it has the prospective application as an energy source. The higher the temperature of the working media is, the higher the thermal efficiency of the energy source (Camot efficiency). The boiling temperature of the electrolyte is a constraint to the temperature of the working media. In a gas-loading system there should be no such constraint. The second advantage of a gas-loading system is its safety feature. The oxygen gas would not appear in a gas-loading D/Pd or H/Pd system; however, the oxygen gas generated in the electrolysis process may form an explosive mixture with the hydrogen gas. The third advantage of the gas-loading system is its reproducibility, because less contamination is involved in this system. Indeed it makes easier for this nuclear transmutation analysis as well.

The International Low Energy Nuclear Reactions Conference (College Station, Texas) was a milestone to open a new branch of anomalous nuclear phenomena in the metal-hydride system. [For proceedings see *J. New Energy*, vol 1, no 1, Jan 1996. –Ed.] Professors Bockris, and Miley, et al., presented compelling evidence showing that the new elements (including Zn) are generated in metal-hydride systems [3,4,5]. It is very difficult to attribute these elements to the impurity contamination. We are particularly interested in Miley's report on the nuclear transmutation result when a single palladium thin film was coated on the plastic beads only (Run #11 in Ref. [2]). The Zn production rate there was 1.57×10^{13} atoms per second per cubic centimeter of palladium, which was the maximum production rate in comparison with those of all other new elements in that run. Indeed, zinc appeared even earlier in the electrolytic experiment with the molten salt as an electrolyte [6]; in the electric discharge system [7], etc. Unfortunately, it was attributed to impurities or uncertainty in the experiments. We suggest that all experimentalists should retrace back to their previous experiments with this new point of view.

"Thunder without lightening" was used to describe the phenomena that excess heat was generated with no commensurate neutron and Gamma radiation. This could be understood in terms of "resonance tunneling of the Coulomb barrier via lattice confined ions" [8,9]. Now we are facing another anomalous phenomenon, i.e. "Lightening without sound." The possible underlined mechanism is also the resonance tunneling of Coulomb barrier. We will discuss this issue in another paper.

ACKNOWLEDGMENTS

This work is partly supported by the State Commission of Science and Technology, the Natural Science Foundation of China (Contract Number 19645005), and the Fundamental Research Fund of Tsinghua University. Professor Wang Jie's help in promoting this research is gratefully acknowledged.

REFERENCES

1. X.Z. Li et al., " 'Excess Heat' Measurement in Gas-Loading D/Pd System," *J. New Energy,* vol 1, no 4, Fall 1996, p 34; see also in "Progress in New Hydrogen Energy," Proc ICCF6., Vol 2, edited by M. Okamoto, pub. New Energy and Technology Development Org., and Inst. of Appl. Energy) p 455.
2 G.H. Miley et al., "Quantitative Observation of Transmutation Products Occurring in Thin-Film Coated Micro-Spheres During Electrolysis," *ibid*., p 629.
3. J.O'M. Bockris et al., "Two Zones of 'Impurities' Observed after Prolonged Electrolysis of Deuterium on Palladium," *Infinite Energy,* vol 1, no 5 (1996), p 67.
4. G.H. Miley et al., "Nuclear Transmutations in Thin-Film Nickel Coatings Undergoing Electrolysis," *J.New Energy,* vol 1, no 3 (1996), p 5.
5. T. Mizuno et al., "Isotopic Changes of the Reaction Products Induced by Cathodic Electrolysis in Pd," *J. New Energy,* vol 1, no 3 (1996), p 31.
6. B.Y. Liaw et al., "Elevated-Temperature Excess Heat in a Pd+D System," *J. Electroanal. Chem*., vol 319 (1991), p 161.
7. A.B. Karabut et el., "Possible Nuclear Reactions Mechanisms at Glow Discharge in Deuterium," Frontiers of Cold Fusion, Proc. ICCF-3 (1992), edited by H. Ikegami, pub. Universal Academy Press, Inc.,Tokyo, Japan, 1993, p 165.
8. X.Z. Li, "Solving the Puzzle of Excess Heat Without Strong Nuclear Radiation," Proc. ICCF-5, edited by S. Pons, pub. IMRA Europe, 1995, p 285.
9. X.Z. Li et al., "A New Approach Towards Fusion Energy with no Strong Nuclear Radiation," *J. New Energy,* vol 1, no 4, Fall 1996, p 44.

ELEMENT CONVERSION BY ARCING IN AQUEOUS SOLUTION

K. Nakamura [1], Y. Kishimoto [2], I. Ogura [3]

ABSTRACT

Authors have tried arcing within a 0.01 Molar ammonium molybdenate aqueous solution to study whether an element can be converted or not by the action of protons generated by the electrolysis of water. The study proved that the arcing is effective for element conversion in this solution with a nickel anode and a carbon cathode. Solid materials and debris of the electrode generated during arcing were filtered and washed with hot water to remove water soluble components. The residue was measured for radioactivity with a 2-π gas flow counter. The measurement showed that arcing produced radioactive materials. This suggests that arcing in water can result in a certain kind of nuclear reaction.

INTRODUCTION

Since Pons and Fleischmann reported that cold fusion is available by electrolytic process in 1989, there are many researches and papers presented concerning cold fusion despite many negative opinions (for example, by Huizenga [1]). We can see such reports from various fields in ICCF, etc. However, research on arc discharge fusion is limited, having only been reported by R. Sundaresan and J.O'M. Bockris [2] and M. Singh et al. [3]. Authors have tried the arcing within 0.01 Mol. ammonium molybdenate to study whether an element can be converted or not by the action of protons generated by electrolysis of water. The study proved that the arcing is effective for element conversion in this solution with a nickel anode and a carbon cathode.

EXPERIMENTAL

Fig. 1 shows equipment configuration used in this experiment. In this figure, (1) is an electrode lead, (2) is a 1 liter glass beaker for arcing container, (3) is electrolytic solution of 0.01 mole/liter of ammonium molybdenate aqueous solution, (4) is an electrode. The cathode uses nickel of 99.9% purity and the anode is graphite of 99.99% purity. (5) in the figure is an electrode holder. It is sealed tightly from water. (6) is a magnetic stirrer to stir the solution. Water used is normal distilled water. Ammonium molybdenate is from commercial grade guaranteed reagent

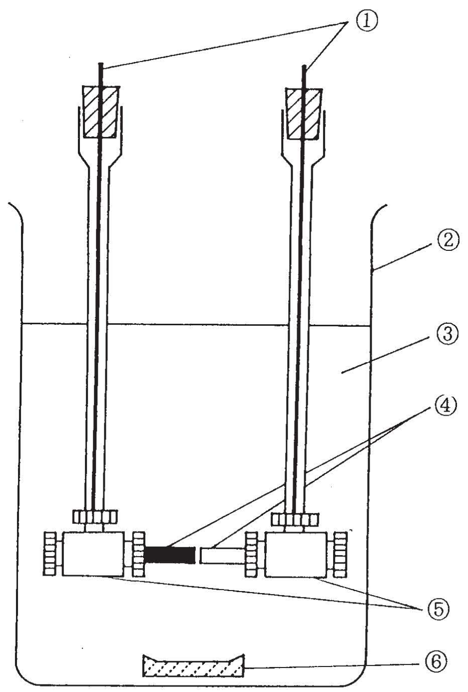


Fig. 1 Equipment employed for Arcing
1. electrode lead 2. container
3. electrolytic solution 4. electrode
5. electrode holder 6. magnetic stirrer

[1] Atomic Energy Res. Inst. Kinki Univ., Kowakae, Higashiosaka, 577 Japan

[2] Faculty of Science and Technology, Kinki Univ.

[3] Former Professor of Atomic Energy Res. Inst., Kinki Univ.

as it is. Although DC 20 V current is applied for arcing, the distance between electrodes is adjusted manually, so current and voltage during arcing are not kept constant.

Solid materials and debris of the electrodes generated during arcing were filtered and washed with hot water to remove water soluble components; then the residue was dried and crushed to prepare test sample I. Test sample I was left in atmosphere of oxygen at 600°C for about 15 hours to remove carbon component, to make test sample II. The filtrate was evaporated to dry and crushed to prepare test sample III. These samples were measured for their radioactivity with a 2-π gas flow counter.

RESULTS

The measurement has shown that arcing produces radioactive materials. This suggests that arcing in water can result in a certain kind of nuclear reaction.

Table 1. Results of Radioactivity Measurement

Sample No.	Sample Weight (g)	Measuring Time (min)	Counts	B.G.	net cpm/g
I	0.2532	30	2138	27.52	172.79
II	0.2462	90	5539	22.52	158.49
III	0.3122	10	244	27.52	–
IV	0.7601	60	1795	30.30	–

Table 1 indicates results of radioactivity measurement. To know its energy intensity of this radiation from the source of test sample II, radiation attenuation was measured with aluminum shields of different thickness. Table 2 shows the results.

Radioactivity shown in Table 1 is explicitly produced from some other products, not from graphite. Table 1 also illustrates results of radioactivity for debris, IV, generated by similar arcing in distilled water only, which was conducted as a control test. The result explains that the resultant radioactivity was induced from ammonium molybdenate of solute.

Table 2. Radiation Attenuation by Al Shielding

Shield Thick-ness (mg/cm^2)	Measuring Time (min)	Counts	B.G. (cpm)	net cpm/g
0.	90	5539	22.52	158.49
3.81	90	4840	22.52	126.97
7.62	180	9044	22.52	112.59
11.43	180	8576	26.04	87.73
15.24	180	8334	26.04	82.29
19.05	270	12294	25.22	82.49

Note: Sample weight is 0.2462 g.

Table 2 shows that an aluminum shield thicker than 11.43 mg/cm^2 is not effective for radiation attenuation, which indicates the existence of X-rays or gamma rays. The effects of X-rays or gamma rays were subtracted from the measured values and the differences were replotted in Fig. 2. This is considered an absorption curve due to aluminum for the produced beta radioactivity. The figure presents the maximum range as about 25 mg/cm^2 and the maximum energy as about 0.13 MeV from Feather's equation. This does not agree with that from ^{99}Tc (0.293 MeV) but is acceptable in the sense of order. The radioactivity hardly decays in about five months, showing its half life is very long.

From the above results, it is reasonable that protons produced by electrolysis of water based on Eq. (1) are excited to react with molybdenum nuclei as shown in Eq. (2).

$$H_2O \rightarrow H^+ + OH^- \quad (1)$$

$$p + Mo \rightarrow Tc + h\nu \quad (2)$$

In general, the reaction as shown in Eq. (2) is considered to difficult to occur because of Coulomb barrier. A calculation says that injection of protons into molybdenum nuclei like in this experiment need energy more than 9.17 MeV. It is not clear whether such energy can be obtained by arcing or not, but five repeated tests provided same results. This suggests reliability of Eq. (2) is very high. Natural abundance of ^{98}Mo in molybdenum is 24.13% and ^{96}Mo and ^{95}Mo also exist at 16.68% and 15.92% respectively. These isotopes, if reacting based on Eq. (2), are converted to ^{97}Tc and ^{96}Tc, which decay in electron capture mode. X-rays or gamma rays detected at the radioactivity measurement are expected to be X-rays produced at this disintegration. Because it is difficult to measure what amount of input is supplied, $h\nu$ in Eq. (2) is unknown to be positive or negative, but a rapid rise in temperature of the solution was observed during arcing, so the reaction is likely to be exothermic.

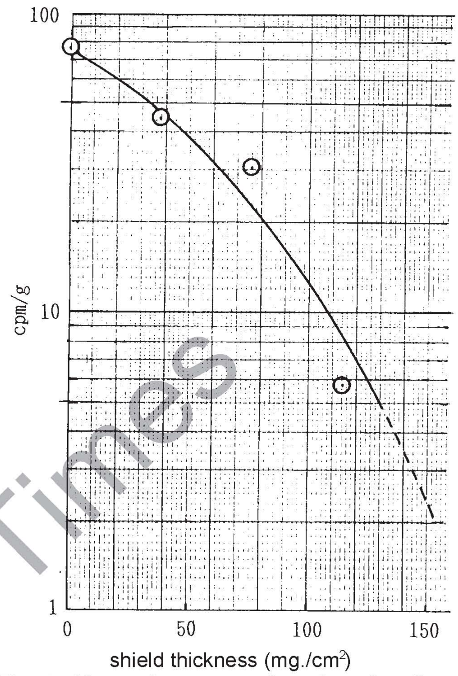


Fig. 2 Absorption curve of produced radio activity in Al.

CONCLUSION

It is possible to apply protons produced in water electrolysis by arcing in water to a nuclear reaction. As a result, it is clarified that the nuclear reaction with solute nuclei in electrolytic solution produced nuclei with original atomic number plus one.

ACKNOWLEDGMENT

The authors thank Dr. T. Yokota for the many important suggestions and encouragement during this work.

REFERENCES

1. J.R. Huizenga, "Cold Fusion the Scientific Fiasco of the Century," (1995).
2. R. Sundaresan, J.O'M. Bockris, "Anomalous Reactions During Arcing Between Carbon Rods in Water," *Fusion Technology*, vol 26, (1994)
3. M. Singh, M.D. Saksena, V.S. Dixit, V.B. Kartha, "Verification of the George Ohsawa Experiment for Anomalous Production of Iron from Carbon Arc in Water," *Fusion Technology*, vol 26, (1994).

NOISE MEASUREMENT IN COLD FUSION SYSTEMS

Dr. Mitchell R. Swartz [1]

INTRODUCTION

In previous reports, we have introduced the concept of routine measurement of background noise power levels in all cold fusion (and other purported over-unity) experiments. Noise analysis can rule out false positive indications of excess energy. Noise measurement can be used for increased accuracy and optimal driving of these complex systems. Furthermore, noise analysis can rule out false positive indications of "excess energy" as described in this paper.

Although this additional experimental requirement has not been widely accepted, it is becoming apparent that those who attempt to clearly define background noise power levels will have provided for better proof of the existence of cold fusion. In addition, this benefit of acknowledging background levels is consistent with what has been reported both for nuclear ash generation (helium [10-11] and tritium [12-17]) and even some autoradiographic experiments. Therefore, better noise detection and measurement in cold fusion (and purported over-unity) systems, supplement recent improvements in calorimetric analysis [4-8] and definitions of input power [9] and can assist in developing better quality data in this field. Background noise power levels should be measured in experiments when possible.

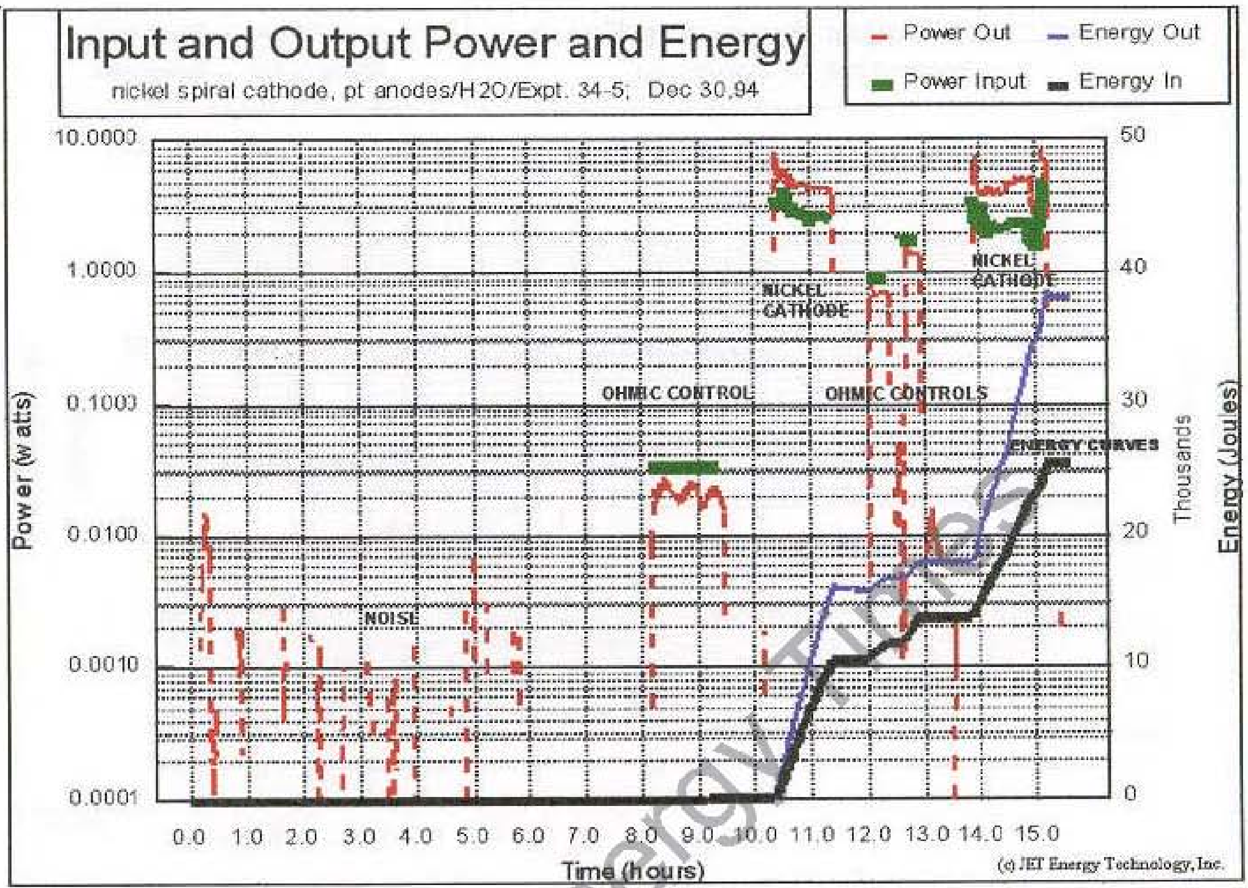
THERMAL SPECTROSCOPIC EVIDENCE OF EXCESS HEAT

Figure 1 shows two thermal spectrographs, with the inclusion of background noise for reactors containing platinum (Fig. 1a) and gold anodes (Fig. 1b) and nickel cathodes [ordinary water (H_20)]. This demonstrates over-unity performance of three different reactors consisting of a light water-nickel cathode (JET Energy Technology 701) vs. a platinum anode (Fig. 1a) or gold anode (Fig. 1b). As is customary in such thermal spectrograms, both the input, and output power, and also the input and output energies are shown to rule out any possibility of stored energy appearing as a pseudo-excess "heat". Also in Fig. 1, for these cold fusion electrolysis systems, the initial noise levels are clearly demarcated, with the noise power level read off of the logarithmic power scale. Fig. 1a shows the results of the nickel light water system using platinum anode. The input and output power and energies of a platinum foil anode (area 4.0 cm^2) and spiral nickel cathode (area 4.8 cm^2, volume 0.059 cm^3) in ordinary light water [H_20]. The step-like functions are the energy curves [read off the right y-axis]. The powers (thermal background, input, output) are the remainder of the curves and have a logarithmic scale (left y-axis). To the lower left, thermal noise is shown (background for this experiment) ranging from ~20 to a few milliwatts. The first input (control) pulse is at -8 hours. The first, third, and fourth input pulses are the controls.

Fig. 1b shows the results of the nickel light water system using multiple nickel cathodes and gold anode. Six spiral nickel cathodes (combined cathodic area 28 cm^2, volume 0.35 cm^3) were used. To the lower left is shown thermal noise (background for this experiment) ranging from 90 to 60 milliwatts and extending until the first input (control) pulse at about 12 hours. These nickel light water systems were characterized by excess heats in contrast to the ohmic controls. For the nickel spiral cathodes with platinum foil anodes, the peak power amplification [$P_{OUT}/P_{IN} = \Pi_{Ni}$] were in the range of $2.27^{\pm 1.02}$. Peak power outputs have been in excess of 2 watts, with power densities (nickel) of more than $7^{\pm 4.3}$ watts/cm^3.

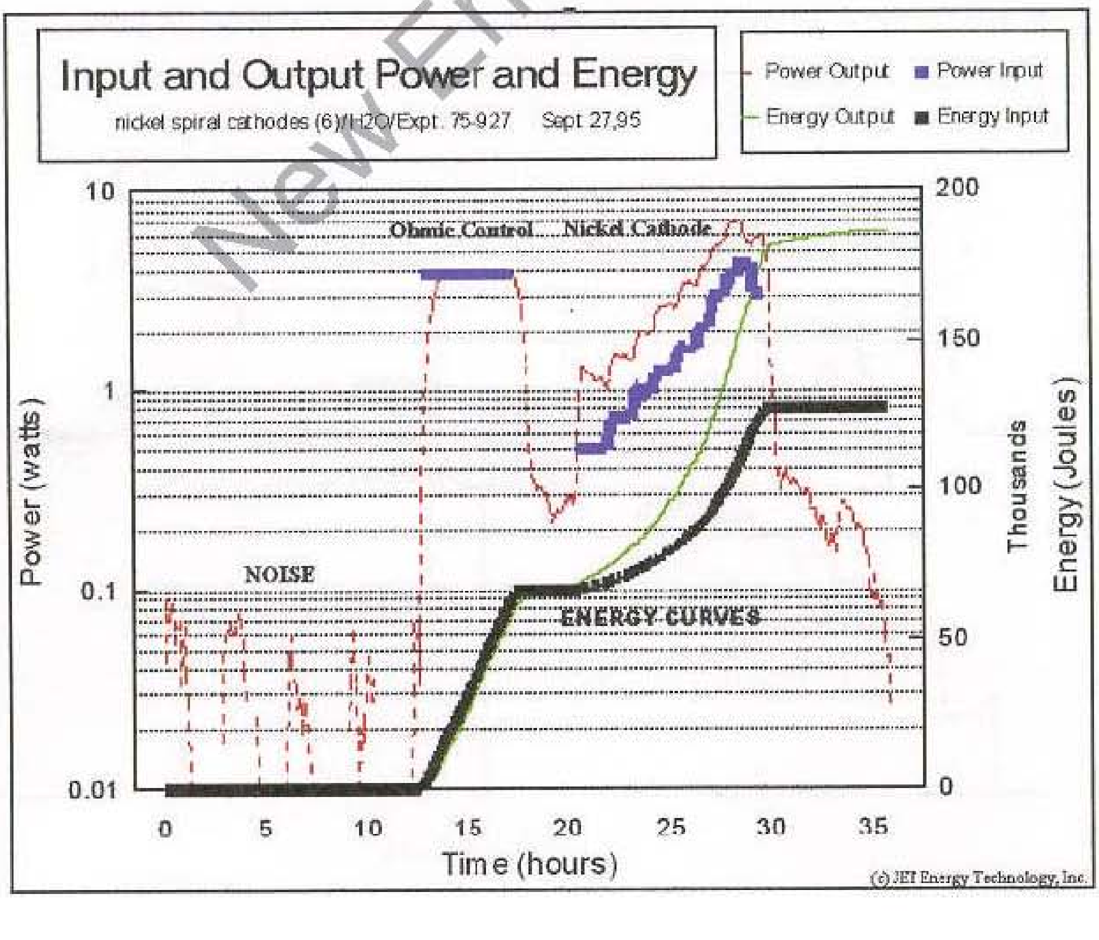
[1] JET Energy Technologies, Inc.

Fig. 1a



Input and Output Power and Energy
nickel spiral cathode, pt anodes/H2O/Expt. 34-5; Dec 30,94
Power Out
Energy Out
Power Input
Energy In
Power (watts)
10.0000
1.0000
0.1000
0.0100
0.0010
0.0001
50
40
30
20
10
0
Thousands
Energy (Joules)
NICKEL CATHODE
NICKEL CATHODE
OHMIC CONTROL
OHMIC CONTROLS
ENERGY CURVES
NOISE
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0
Time (hours)
(c) JET Energy Technology, Inc.

Fig. 1b



Input and Output Power and Energy
nickel spiral cathodes (6)/H2O/Expt. 75-927 Sept 27,95
Power Output
Power Input
Energy Output
Energy Input
Ohmic Control
Nickel Cathode
NOISE
ENERGY CURVES
Power (watts)
10
1
0.1
0.01
200
150
100
50
0
Thousands
Energy (Joules)
0 5 10 15 20 25 30 35
Time (hours)
(c) JET Energy Technology, Inc.

Fig. 2a

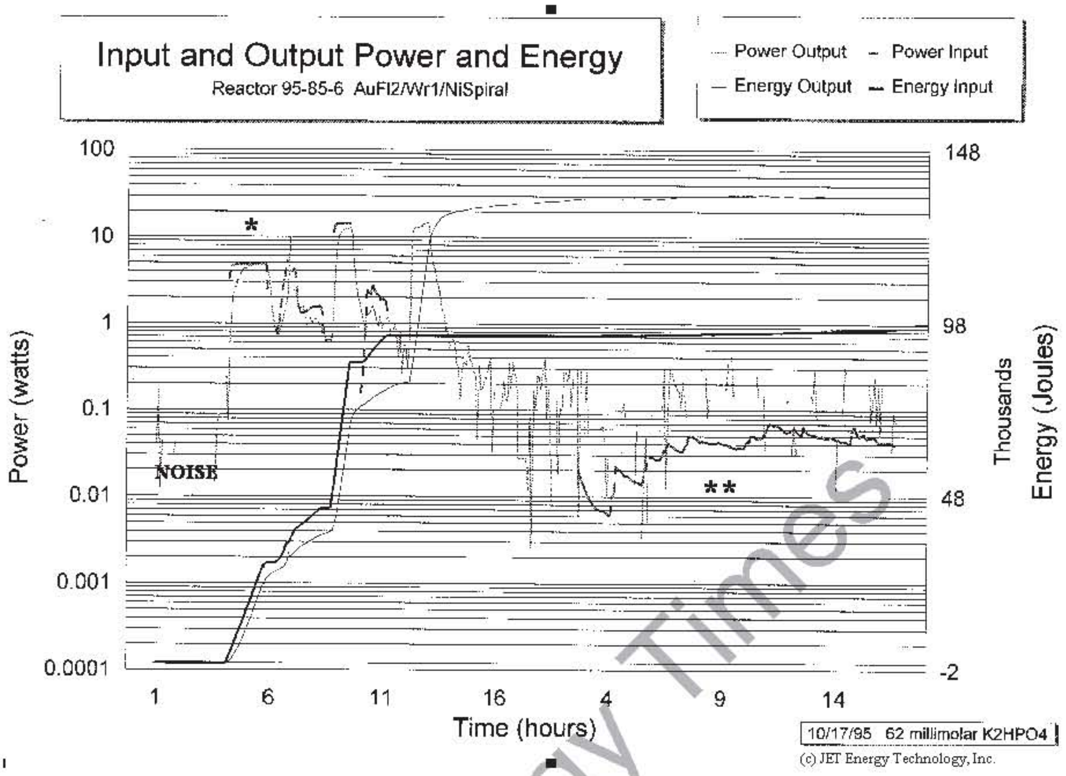
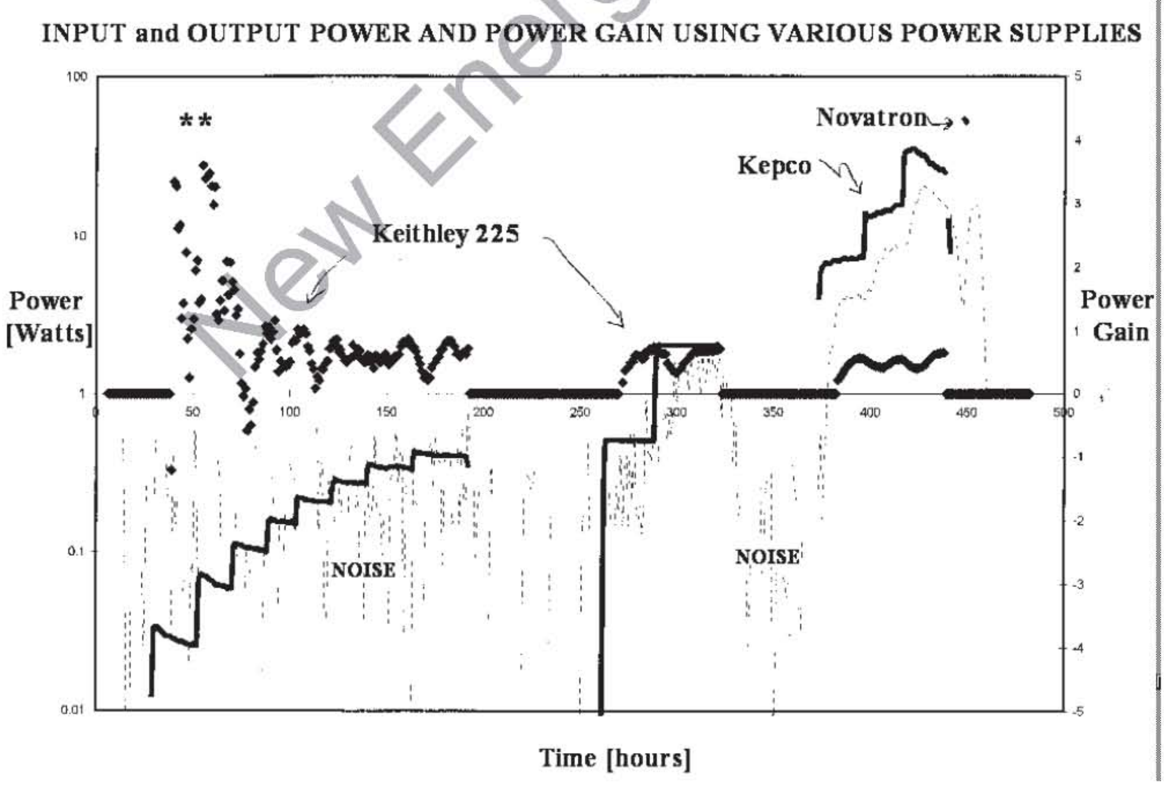

Input and Output Power and Energy
Reactor 95-85-6 AuFl2/Wr1/NiSpiral
Power Output
Power Input
Energy Output
Energy Input
Power (watts)
Thousands Energy (Joules)
NOISE
Time (hours)
10/17/95 62 millimolar K2HPO4
(c) JET Energy Technology, Inc.

Fig. 2b


INPUT and OUTPUT POWER AND POWER GAIN USING VARIOUS POWER SUPPLIES
Power [Watts]
Power Gain
Novatron
Kepco
Keithley 225
NOISE
NOISE
Time [hours]

What can be clearly seen is both the advantage of the long term initial baseline (characterizing the background noise spectrum), and that the control input pulses (ohmic resistance) resulted in less than unity efficiency of heat production. It is clear that the drive energies far exceed the background noise level, and therefore the nickel generators clearly demonstrate over-unity performance. It has been reported that such noise measurements and thermal spectrograms have led to the detection, and use, of the π-notches, within which is the correct location to drive the reactors. In this paper, we report that false positives of excess heat can also be detected, and eliminated, by thermal spectroscopy.

THERMAL SPECTROSCOPY RULES OUT FALSE POSITIVES

Although noise measurement is thus demonstrated to be important because it improves the quality of the derived information, it may rule out erroneous indications of over-unity which can be artificially produced under certain conditions. For example, Fig. 2 clearly shows two instances of how driving a reactor below the noise level can give the appearance of "over-unity". Driving a system with input energies of magnitude less than the average noise energy level will obviously yield an output at or slightly above the original noise level. This false "over-unity" occurs because the computed yield of "over-unity" is defined as the energy in the noise spectrum and output energy divided only by the input energy.

Fig. 2a shows a thermal spectrogram obtained from a nickel light water system reactor using a gold foil anode which degraded by 11 hours yielding copious contamination materials from the gold substrate, and inactivity. The only sign of activity prior to that was at the star (*; investigated in other studies and not shown here). Attention is direct to the region marked by the double stars (**). There the electrical input is below the noise level. This yields a false "excess heat", clearly revealed by the spectroscopy. In Fig. 2a, to the lower left can be seen the initial thermal noise which in this system was set deliberately to be in the range of 20 to more than 100 milliwatts. The first input (control) pulse is at ~4 hours. The first and third input pulses are the controls. The amount of time the reactors was actually producing excess heat was very short (*), and would have been easily missed without the spectroscopy. The locating of the π-notch, and the enabling of the correct "tuning" of the system by driving in that region (*) has been covered elsewhere. The issue here is that the thermal spectrogram does additionally rule out the region of false possitivity (labeled with the double stars * *).

Fig. 2b shows a second inactive reactor for an entirely different reason. Our work has focused upon the role of phonons in these reactions, and it is suggested by some of our research but not proven that secondary to massive removal of phonons which are required for the coupling of the nuclear reactions to the lattice, these reactors can become inactive. This particular "phonon-drained" system was composed of a light water system with a single nickel cathode and gold anode. Several power supplies were used to electrically drive system (Keithley 225 current source, Kepco voltage source, Novatron power source) and are labeled on the figure. This particular thermal spectrogram does not include energy, but does give the over-unity factor on the right which corresponds to the solid large dots on the left, and solid wavy lines on the right. The solid lines are input power, and the dotted lines are the detected output power. The reactor (no controls in this portion of the data shown) generally subunity performance except for the appearance of false positives. These are apparent in the beginning range of about 50 to 100 minutes. It is easy to see that at those times the input power level was below the noise power level (ranging to a fraction of a watt), and as a result did produce the appearance of false positive "excess heat". This false possitivity is very important and avoidable. This is a false factor of more than 300%, and yet the thermal spectroscopy clearly demonstrates the false possitivity.

In summary, these cases of erroneous false "over-unity" are saliently demonstrated -- by thermal spectroscopy -- to be **NOT** over-unity. Unless thermal spectroscopy (Fig. 1a, 1b, 2a, 2b) is carefully undertaken to make observable the background noise power levels, it may be difficult to rule out such potential false positives.

FALSE DEFINITIONS OF NOISE

Noisy urban legends percolate regarding noise. They range from the silly anecdotes of the "advantage" of fixing a broken - or stuck - sensor to more serious suggestion regarding the applicability of stochastic resonance [18-19]. Stochastic resonance occurs in some nonlinear systems, and is noted in select cases of detection where a **signal intensity is below the sensitivity of the detector**. Specifically, it involves the occasional detection of a weak periodic signal located in a noise spectrum. From a power-spectrum point-of-view, the impact of the random fluctuations (noise) is that coherence of a weak periodic signal may be optimized in such non-linear subthreshold cases. The functional impact of the applied noise upon the weak periodic signal is to enhance the detection of the -- previously undetectable -- signal. Thus, stochastic resonance is important to biological neural systems including hearing and perhaps other near-threshold senses, and may also be important to magnetic flux driven sensitive detection devices. But do subthreshold conditions, where sensors have sensitivities below the signal level, exist in the field of cold fusion or other purported over-unity devices?

Although there is benefit from additional energies inserted into cold fusion systems (both with non-ionizing radiation, with positive feedback, and also various magnetic and electric devices), closer analysis suggests this to not be the case for the detection side. Given noise and signal processing theory involving these low threshold linear detection systems, it seems unlikely that based upon stochastic resonance, noise in cold fusion systems would be actually be beneficial on at least two (2) counts. First, excess heat, if and when it exists, is not AC. Presumably over the times of examination, the output in a large volume will appear as something other than a weak periodic signal. Second, the thermometry is not a problem. Also, there is no sensitivity problems for either thermocouples, thermistors, or other temperature measurements devices. If the excess heat is there say at 100 milliwatts, it will definitely be detected. There is no threshold sensitivity in such thermometry whatsoever.

CONCLUSIONS AND SUMMARY

In summary, noise analysis can assist in developing better quality data in this field, and should be measured in experiments when possible. Noise analysis can improve signal detection accuracy and sensitivity and therefore the quality of reports. It can be used to find the optimal drive conditions in such systems. Furthermore, in putative over-unity devices, a driving input with energies on the order of, or less than, the energy in the noise, can give erroneous "over unity" results, if the results do not include a measurement of the noise. Such artifact may make the appearance of "excess heat", but it is probably not, and if it is, it is clouded in the noise itself. Finally, although exogenous energy, including feedback control, influence cold fusion systems and stochastic resonance are real, stochastic resonance does not appear to apply to these systems, and probably would not improve signal accuracy or sensitivity.

REFERENCES

1. M. Swartz, "Consistency of the Biphasic Nature of Excess Enthalpy in Solid State Anomalous Phenomena with the Quasi-l-Dimensional Model of Isotope Loading into a Material," *Fusion Technology*, vol 31, January (1997), pp 63-74.
2. M. Swartz, "Possible Deuterium Production from Light Water Excess Enthalpy Experiments Using Nickel Cathodes," *Journal of New Energy*, vol 1, no 3 (1996), pp 68-80.

3. M. Swartz, "Biphasic Behavior in Thermal Electrolytic Generators Using Nickel Cathodes," 32nd Intersociety Energy Conversion Engineering Conference (July 1997).
4. M. Melich, W.N. Hansen, "Some Lessons from 3 Years of Electrochemical Calorimetry," Proc. ICCF-4 (1993), sponsored by EPRI and the Office of Naval Research.
5. M. Swartz, "Some Lessons from Optical Examination of the PFC Phase-II Pcalorimetric Curve," Proc. ICCF-4 (1993), vol. 2, pp 19-1, ibid.
6. M. Swartz, "A Method to Improve Algorithms Used to Detect Steady State Excess Enthalpy," *Trans. of Fusion Technol.,* Dec. 1994, vol 26, pp 156-159.
7. M. Swartz, "Potential for Positional Variation in Flow Calorimetric Systems," *J. New Energy*, vol 1 (1996), pp 126-130.
8. M. Swartz, "Improved Calculations Involving Energy Release Using a Buoyancy Transport Correction," *J. New Energy*, vol 1, no 3 (1996), pp 219-223.
9. M. Swartz, "Definitions Of Power Amplification Factor," *J. New Energy*, vol 1, no 2 (1996), pp 54-59.
10. M.H. Miles, R.A. Hollins, B.F. Bush, J.J. Lagowski. R.E. Miles, "Correlation of Excess Power and Helium Production During D_2O and H_2O Electrolysis using Palladium Cathodes," *J. Electroanal. Chem.*, vol 346 (1993), pp 99-117.
11. M.H. Miles, B.F. Bush, "Heat and Helium Measurements in Deuterated Palladium," *Trans. Fusion Technol.*, vol 26 (Dec. 1994), pp 156-159.
12. F.G. Will, et al., "Reproducible Tritium Generation in Electrochemical Cells Employing Palladium Cathodes with High Deuterium Loading, *J. Electroanal. Chem.*, vol 360 (1993), pp 161-176.
13. F.G. Will, F. G,K. Cedzynska, D.C. Linton, "Tritium Generation in Palladium Cathodes with High Deuterium Loading," *Trans. of Fusion Technol.*, vol 26 (1994), pp 209-213.
14. E. Storms, C. Talcott, "Electrolytic Tritium Production," *Fusion Technol.*, vol 17 (1990), pg 680.
15. R. Notoya, Y. Noya, T. Ohnishi, "Tritium Generation And Large Excess Heat Evolution By Electrolysis in Light And Heavy Water-Potassium Carbonate Solutions With Nickel Electrodes," *Fusion Technol.*, vol 26, (1993), pp 179-183.
16. R. Notoya, "Alkali-Hydrogen Cold Fusion Accompanied by Tritium Production on Nickel," *Transactions of Fusion Technol.*, vol 26, (Dec 1994), pp 205-208).
17. M. Srinivasan, A. Shyam, T.K. Shankarnarayanan. M.B. Bajpai, H. Ramamurthy, U.K. Mukherjee, Krishnan, M.G. Nayar, Y. Naik, "Tritium and Excess Heat Generation During Electrolysis of Aqueous Solutions of Alkali Salts with Nickel Cathode," Frontiers of Cold Fusion, Ed. by H. Ikegami, Proc. ICCF-3 (1992), Universal Academy Press, Tokyo, pp 123-138.
18. F. Moss, K. Wiesenfeld, "The Benefits of Background Noise," *Scientific American,*, vol 66, Aug 1995.
19. F. Moss, K. Wiesenfeld, "Stochastic Resonance, The Phenomenon by Which Background Noise Boosts Weak Signals is Creating a Buzz in Physics, Biology and Engineering," *Phys Rev Lett.*, vol 77 (1996), pp 4098; *Nature*, vol 365 (1993), pp 337.

CAN LOW-ENERGY NUCLEAR REACTIONS BE CONTAINED IN METAL DEUTERIDES?

Roman Edmund Sioda [1]

AUTHOR'S ABSTRACT

The model of "cold fusion," which assumes the existence of local "hot spots" in deuterated metals – hypothetically producing excess heat and some "nuclear ashes," requires a further detailed discussion, concerning its validity, scope and characteristics. Some of these questions are being discussed, especially what concerns the properties of "plasma" in a developed "hot spot" – in the light of the kinetic theory of gases.

"Cold Fusion" remains an experimental and theoretical mystery, since it was rediscovered in 1989 [1,2]. During the recent years, this author, and a coauthor (Kühne), have worked out a hypothetical "hot spot" mechanism of the "cold fusion" phenomenon [3-8]. This concept is a development of the idea published by Seitz in a letter to *Nature*, that the block of deuterated metal may contain localized "hot spots," where hot fusion takes place [9]. The interesting idea has been substantiated with experimental data from literature [3], and a mathematical model has been presented for the heat exchange between the hypothetical hot spots and the block of metal [4-8]. This model allows to link the radius (R) of the "hot spot" with the apparent temperature (T, Kelvins) of the plasma inside the "hot spot" by a simple equation:

$$RT^4 = kt_m/\sigma \quad (1)$$

where k is the thermal conductivity of the deuterated metal block, t_m is the melting point of the metal (in degrees Celsius), and σ is the Stefan-Boltzmann constant [4,5]. Equation (1) seems important, as it allows to estimate the average temperature of the plasma, if the radii of the "hot spots" can be measured by a post-experimental survey of the deuterated block of metal, as it has been done and described by Karabut et al. [10]. This approach seems to be an important development, allowing the first macroscopic, structural parameters to be determined for "cold fusion" experiments.

It is also of interest to note several recent papers devoted to low-energy nuclear transmutations [11-13]. However, this work is extremely complex from the experimental point of view and, thus, difficult to evaluate immediately. There are also controversies, which concern especially the paper by Miley and Patterson [11], using a flow-type electrolytic cell, as such a cell may be collecting impurities from larger volumes of circulating solution. This effect had already been discussed by Sioda and Keating for extended-surface electrodes [14], and by Sioda and Fahidy for trace-elements preconcentration using flow methods [15-17]. It seems that this research area requires extensive further experimental studies in the scope of behavior of trace metal impurities under conditions of exhaustive electrolysis. A theoretical model of such processes had already been worked out [18,19], with preliminary experimental support [20].

The aim of the present paper is to analyze further the "hot spot" hypothesis, especially concerning its energetics and plasma physical properties.

[1] Institute of Industrial Organic Chemistry, Warszawa-Zeran, Poland

RESULTS

If the above ideas are to be of value, it is important to know the properties of hydrogen isotopes, and especially of deuterium, at very high pressures. Fortunately, a very recent paper by Weir et al. has been published, where it is shown that inducing fluid molecular hydrogen and deuterium to very high shock pressures (over 0.93 Mbar) causes them to become "metallic", i.e. to increase their conductivity by almost 4 orders of magnitude to a stable value, typical for liquid metals at 1.4 to 1.8 Mbar pressure. During the shock compression process in the range of 0.93-1.8 Mbar pressures, lasting for only approx. 200 ns, the temperature of the liquid hydrogen increases from the initial 20 K to 2200-4400 K, and density increases to 0.28 - 0.36 mol/cm^3 (1.2-1.5 g/cm^3 for molecular deuterium), according to calculation of authors. The compressed sample is very small (approx. 40 mg of liquid deuterium), which makes prospective, radiometric experiments difficult to consider [21]. The highly compressed hydrogen and deuterium behave typically like liquid metals in the thermodynamic and conductivity sense [22, 23].

Fusion of deuterium comes naturally to mind, as this is a highly energetic process, which is well-known to proceed by three main channels with energy gain Q and probabilities P [24]:

$$d + d \Rightarrow {}^3He\ (0.817\ MeV) + n\ (2.452\ MeV)\ , \quad Q = 3.269\ MeV, \quad P \approx 0.5\ , \tag{2}$$

$$d + d \Rightarrow p\ (3.025\ MeV) + t\ (1.008\ MeV)\ , \quad Q = 4.033\ MeV, \quad P \approx 0.5\ , \tag{3}$$

$$d + d \Rightarrow {}^4He\ (7.6\ keV) + \gamma\ (23.7\ MeV)\ , \quad Q = 23.8\ MeV, \quad P \approx 10^{7} \tag{4}$$

It is the present author's belief that the above equations have only a limited relation to the "hypothetical" cold fusion phenomenon. Those equations are energetically correct, following from the recalculation in terms of energy of the "mass defect," by means of Einstein's equation. Otherwise, the reactions contain only limited experimental information; it is, e.g., assumed that deuterons are fully ionized (no electrons present) and are free to move thermally. Their thermal energy must be very high (a few tens of keV at least) so that the Coulomb barrier between the approaching deuterons can be overcome directly, or by a tunneling mechanism, in a point-blank collision. Naturally, the kinetics of the actual fusion process is highly complicated, and depend on the complete description of the fusing mixture, including other ions, atoms or electrons present. Especially, in "cold fusion" studies the deuterons are not free to move, as they are constrained in a metal block, composed of heavy nuclei and a multitude of electrons. Some of them are tightly bound with the nuclei in deep shells, while others are free to form bonds (valence electrons) and to move in the conduction band (conduction electrons). The situation is so specific here that, according to Lehnert "cold fusion" forms the fourth subdivision of fusion research, along with magnetic confinement and inertia confinement (both hot fusion) and muon catalysis (cold fusion), under the name of "metal catalysis." Lehnert characterizes "metal catalysis" as an "implantation of deuterium and tritium in the interatomic spacing of a metal," which leads to "high particle density," and was "first attempted in 1926" with "new attempts in 1989" and on [25].

Thus, it becomes evident that the hot fusion nuclear reaction scenario, as realized in high-energy tokamaks and inertial fusion laser systems, is not adequate for cold fusion conditions, especially as concerns the "metal catalysis" scenario. Here, the mutual interactions of particles are so complex that they are practically impossible to compute by classical quantum mechanical methods. For example, the electronic structure of Pd/H or Pd/D systems has not been yet calculated, and even insufficient experimental results exist to describe their molecular and electronic structure; it is not yet known if H_2 or D_2 do exist in Pd in a molecular, ionic or molecular-ionic form. The character and extent of mobility of H and D particles in Pd is also not well understood, although the mobility is observed on a macroscopic level, and described by a diffusivity parameter of the order of $10\ ^{7}$ cm^2 /s [26].

The second important aspect of the "cold fusion" reaction is containment. It seems that for slow, controlled "cold fusion" reaction, the block of metal containing deuterium, supplies an almost **perfect and absolute containment**, based on the rigid, crystallographic lattice of the metal. The metal not only "contains" the fuel (deuterium), it also may change the course of fusion reaction, by accepting the energy and momentum of an elemental fusion process. In hot fusion of magnetic and inertial containment experiments, the most probable "channels" of fusion processes are those where the energy is about equally redistributed to allow conservation of momentum (channels 2 and 3). Channel 4 is not probable, as the energy is very unequally distributed between the formed α-particle and γ-ray to preserve momentum. In the metal-containment experiments of "cold fusion" process, the energy and momentum of the fusion process can be given directly to the metallic lattice, and thus, the most energetic channels of fusion reaction will be favored, i.e. the modified channel 4, i.e. there is no limitation on the realization of the fusion channel due to the conservation of momentum law, and the channel producing the largest amount of energy, as heat, is realized:

$$d + d \Rightarrow {}^4He + Q(heat) \qquad (5)$$

The initial excitation and ignition of "cold fusion" reaction will create a local "hot zone" of highly energetic and ionized deuterium atoms, deuterons, contained in the metallic lattice. They may fuse further, causing that the metallic grid will melt and vaporize locally, forming a "hot spot," a cavity filled with hot, ionized, deuterium plasma [3-8]. According to Karabut et al. [10], palladium excited with deuterons of energies of 0.1 to 0.5 keV (formed in a glow discharge) after a "cold fusion" experiment contains a multitude of small cavities of typical dimensions of 100 - 1000 Angstroms and a density of $10^{14}/cm^3$. The cavities were observed with transmission electron microscope close to the surface of the palladium sample, to the depth of 1000-10,000 Angstroms. Taking the geometric average of the observed dimensions of cavities, one obtains the average radius of R_{av} = 1.6×10^{-6} cm. Using the equation (1), it follows that for palladium:

$$R\,T^4 = 2.0 \times 10^{14}\ cm^* K^4, \qquad (6)$$

and substituting R_{av} = $1.6 \times 10\ ^{6}$cm, one obtains the average plasma temperature, $T = T_{av}$ = 105,000 K, i.e. 9.2 eV (E = kT, where k is the Boltzmann constant). 9.2 eV average kinetic energy of plasma in the hot spot compares subsequently with the ionization potential of hydrogen of 13.589 eV, and that of hydrogen molecule to form molecular ion H_2^+ of 15.50 eV (the respective values for deuterium are not very much different). Naturally, the above value of 9.2 eV is an average value, and taking into account the Maxwellian velocity distribution, we can expect a high proportion of deuterium molecules ionized at T_{av} = 105,000 K. It is also probable that this value of temperature characterizes the plasma particles close to the wall of the cavity, and in the center of the cavity much higher plasma temperatures exist [27]. This supposition is in accordance with that of Moss et al., who studied by simulation the possibility of micro-thermonuclear fusion in deuterium bubbles under sonoluminescence experimental conditions [28]. They have found that – under special conditions of composition and acoustic pressure function characteristics – the temperatures in the center of the bubble may reach values of about 2 keV, i. e. enough for initiation of hot fusion, according to tunneling-collision mechanism! It is possible to consider that in the "hot spot" inside a metal deuteride, similar conditions for hot fusion may exist.

Taking into consideration the palladium deuteride, it has been experimentally found that "cold fusion" can be observed, when palladium absorbs the highest possible amount of deuterium, which corresponds to atomic ratio of Pd to D of approximately 1 to 1 (1 to 0.95 - 0.97 to be more exact) [29,30]. It is, thus, possible to calculate that in palladium deuteride of the above composition, the density of deuterium atoms is 6.8 x 10^{22} atoms/cm^3. Assuming that in the "hot spot" cavity there is about the same density of deuterons, i.e. there is no significant transfer of deuterium from or to the cavity and the surrounding metal block (across the cavity "walls"), and also assuming that all deuterium exists in atomic or ionic (deuteron) form, it follows that the average pressure inside the "hot spot" cavity will be about 0.97 Mbars (million atmospheres), calculated from the ideal gas law for T_{av} = 105,000 K. Naturally, those are only approximate values, however, they can give an important insight.

According to the recent paper by Weir et al., deuterium under pressures exceeding approx. 1.4 Mbar becomes metallic and forms a special state of matter [21]. The authors could not, however, keep this state of deuterium for more than about 200 ns. If a "hot spot" exists in palladium deuteride, it is possible that it "lives" for much longer, even for periods of seconds, or even longer. The time-limitation to the existence of a "hot spot" will probably be the extinction of the "cold fusion" reaction by too strong admixture of the palladium ionized vapor in "hot spot" plasma.

Multiplying the volume of an average "hot spot" cavity (1.7 x 10 ^{17} cm^3) by the atomic density of deuterium in palladium deuteride (6.8 x 10^{22} atom/cm^3), it follows that an average "hot spot" cavity contains 1.2 x 10^6 deuterium atoms. If all deuterium atoms could fuse according to d(d,^{4}He)Q channel, the total fusion energy content of a single, average "hot spot" would be 4.6 x 10 ^{6} J. It is reasonable to assume that, maybe 10% of that value could be obtained as heat, i.e., about 10% of deuterium contained in a "hot spot" could fuse, producing ^{4}He and heat, as the main products. Although, hypothetical heat produced by a single "hot spot" may not seem high, there may exist a tremendous number of such hot spots inside a block of palladium deuteride (according to Karabut et al., on the order of 10^{14}/cm^3 at the surface layer of Pd).

It is difficult to hypothesize at present about the composition and structure of the plasma inside the "hot spot." There may be a strong interaction of deuterium with palladium metal or vapor. Assuming, however, that the main component of the plasma is deuterons, because of their very small radius, on the order of 10 ^{13} cm, there seems to be a lot of space to move inside a "hot spot" cavity of R_{av} = 1.6 x 10 ^{6} cm. So, taking into account the smallness of a deuteron, the cavity seems very huge, about 7 orders of magnitude larger than the deuteron itself! At T_{av} = 105000 K, the average velocity of deuterons is v_{rms} = 3.6 x 10^4 m s ^{1}, according to the kinetic theory of gases. Assuming that the deuteron has an average radius of the order r_o = 3 x 10 ^{15} m, it follows further that in the "hot spot" cavity of the density of 6.8 x 10^{28} deuterons/m ^{3}, the average deuteron collides with other deuterides about 7 x 10^4 times/second. Thus, the between-the-collisions distance (free path) is about 0.5 m, which is about 15 x 10^6 times larger, than the average diameter of a hypothetical "hot spot" cavity! Consequently, the plasma of the "hot spot" cavity is **virtually transparent** for deuterons at the "hot spot" elevated temperatures (T_{av} = 105000 K), and the deuterons must strike practically endlessly the "walls" of the cavity (about 15 x 10^6 times}, before, they can collide with another deuteron in the hot zone of the cavity. It is, thus, possible that fusion and possible other nuclear reactions take place predominantly at the "walls" of the "hot spot" cavity, where there are palladium lattice atoms, and electronic effects should play a decisive role in collisions!

It is hoped that the above discussion of a hypothetical explanation of "cold fusion" by the "hot spot" mechanism may lead to a better theoretical understanding and experimental verification of the "hot spot" concept. This concept has the advantage of having a "physical meaning," and seems not to contradict the classical quantum mechanics, as some other models of "cold fusion" seem to do. It is also the aim of this model to combine and use the knowledge collected in the international, "hot fusion" research to analyze the possibility of "cold fusion" phenomenon in the metal containment conditions.

REFERENCES

1. M. Fleischmann and S. Pons, *J. Electroanal. Chem.*, vol 261, p 301 (1989); also M. Fleischmann, S. Pons, M. Hawkins, Errata, ibid., vol 263, p 187 (1989).
2. S.E. Jones et al., *Nature*, vol 338, p 737 (1989).
3. R.W. Kuhne, R.E. Sioda, *Fusion Technol.*, vol 27, p 187 (1995).
4. R.E. Sioda, *Current Topics in Electrochemistry* (India), vol 3, p 349 (1994).
5. R.E. Sioda, *"Cold Fusion"*, no 11, p 19 (1995).
6. R.E. Sioda, *"Cold Fusion"*, no 12, pp 5-6 (1995).
7. R.E. Sioda, *"Cold Fusion"*, no 16, p 21 (1996).
8. R.E. Sioda, *"Cold Fusion"*, no 19, p 28 (1996)
9. R. Seitz, *Nature*, vol 339, p 185 (1989).
10. A.B. Karabut, Ya. R. Kucherov, I.B. Savvatimova, *Phys. Lett. A*, vol 170, p 255 (1992).
11. G.H. Miley, J.A. Patterson, *J. New Energy*, vol 1, no 3, p 5 (1996).
12. T. Mizuno, T. Ohmori, M. Enyo, *J. New Energy*, vol 1, no 3, p 31 (1996).
13. R. Bass, R. Neal, S. Gleason, H. Fox, *J. New Energy*, vol 1, no 3, p 81 (1996).
14. R.E. Sioda, K.B. Keating, *Electroanal. Chem.* Series (A.J. Bard, Editor), vol 12, pp 1-52, Marcel Dekker, New York (1982).
15. R.E. Sioda, *Anal. Chim. Acta*, vol 228, p 323 (1990).
16. T.Z. Fahidy, R.E. Sioda, *Anal. Chim. Acta*, vol 232, p 401 (1990).
17. T.Z. Fahidy, R.E. Sioda, *Anal. Chim. Acta*, vol 22, p 347 (1992).
18. R.E. Sioda, *Anal. Chem.*, vol 60, p 1177 (1988).
19. R.E. Sioda, T.Z. Fahidy, *Anal. Chem.*, vol 62, p 550 (1990).
20. A. Ciszewski, J.R. Fish, T. Malinski, R.E. Sioda, *Anal. Chem.* , vol 61, p 856 (1989).
21. S.T. Weir, A.C. Mitchell, W.J. Nellis, *Phys. Rev. Lett.*, vol 76, p 1860 (1996).
22. F. Hensel, P. Edwards, *Phys. World*, April 1996, p 43.
23. N. Ashcroft, *Phys. World*, July 1995, p 43; also R.J. Hemley, N.W. Ashcroft, *Nature*, vol 380, p 671 (1996).
24. M. Rabinowitz, Y.E. Kim, V.A. Chechin, V.A. Tsarev, *Trans. Fusion Technol.*, vol 26, p 3 (1994); also V.A. Chechin, V.A. Tsarev, M. Rabinowitz, Y.E. Kim, *Intern. J. Theoret. Phys.* , vol 33, p 617 (1994).
25. B. Lehnert, *J. Tech. Phys*, (Warsaw), vol 36, p 115 (1995).
26. A. M. Riley, J.D. Seader, D.W. Pershing, C. Walling, *J. Electrochem. Soc.*, vol 139, p 1342 (1992).
27. C.E. Bennett, private communication (1996).
28. W.C. Moss, D.B. Clarke, J.W. White, D.A. Young, *Phys. Lett. A*, vol 211, p 69 (1996).
29. G. Mengoii, M. Fabrizio, C. Manduchi, G. Zannoni, *J. Electroanal. Chem.*, vol 350, p 57 (1993).
30. F.G. Will, K. Cedzynska, D.C. Linton, *J. Electroanal. Chem.*, vol 360, p 161 (1993).

TORSION FIELDS AND THEIR EXPERIMENTAL MANIFESTATIONS

A.E. Akimov [1], G.I. Shipov

ABSTRACT

The methods of incorporating torsion fields into the objects of theoretical physics are pointed out. Major properties of torsion fields are cited. Examples of torsion fields' symptoms in fundamental experiments are considered. Critical applied and technological employments of torsion fields are outlined.

INTRODUCTION

Over the course of the last decades, it was constantly stated that all familiar phenomena of nature and experimental results were explained by four known interactions: electromagnetism, gravitation, strong and weak interactions. However, in the last fifty years, around twenty anomalous research results remain without any explanation within the framework of these interactions [1]. It will suffice to point out the works of H. Tetrode [2] and A.F. Fokker [3] and later, those of J. Wheeler and R. Feynman [4, 5], as well as other authors. However, these works failed to receive their rightful boost. Only torsion fields concepts constituted an exception.

The torsion fields (spin fields) theory is a traditional trend in theoretical physics dating back to the works of the second half of last century. Nonetheless, in its present-day mold the theory of torsion fields has been formulated owing to the ideas of Eli Cartan, who was the first to indicate clearly and definitely that in nature there exist fields generated by spin angular momentum density. To date, world periodicals' references to torsion fields amount to around 10,000 articles belonging to about a hundred authors. Over one-half of those theorists work in Russia.

In spite of a sufficiently elaborated theoretical body, the study of torsion fields had persisted to be a solely theoretical subject until the early 1970s. Due to this fact, they failed to become as universal a factor as electrodynamics or gravitation. More than that, there existed a theoretical inference that since the constant of spin-torsion interactions was proportional to the product of G x $\hbar$, (G - gravitation constant, $\hbar$ - Planek's constant), i.e. it was almost 30 orders of magnitude weaker than gravitation interactions, then even if torsion effects did exist in nature, they could not contribute noticeably to the observed phenomena.

However, in the early 1970s, by virtue of the works by F. Hehl [6-8], T. Kibble [9], D. Seiama [10] et al., it was demonstrated that this conclusion holds true, not for torsion fields in general, but only for static torsion fields generated by spinning sources without radiation.

A considerable number of works on the theory of dynamic torsion (a spinning source with emission) have come out in the ensuing 20 years. These works have displayed that the Lagrangian of the spinning source with emission may contain as many as ten terms with constants that are in no way dependent either on G or $\hbar$; the theory imposes no requirements as to their mandatory infinitesimal. The specialists in the theory of torsion fields are well aware of this fact. Nevertheless, the traditional point of view on the infinitesimal of spin-torsion interactions' constants remained, in the

[1] President of Universe Communication Corp., Costa Mesa, CA.

consecutive 15 years, to be a psychological disturbance for the experimenters that distracted them from an intense and comprehensive search for the experimental manifestations of torsion effects. It was only in the early 80s in Russia that attention was paid to the global role of torsion fields dynamic theory findings. It was then that heed was given to the presence in physics of a vast experimental phenomenology containing many experimental results unexplained in terms of the four known interactions, while denoting the experimental manifestation of torsion effects. With the devising in Russia in the 80s of the world's first torsion field generators, target-designated research work was unfolded and put into effect in numerous directions of searching for torsion fields manifestations, which yielded a large volume of practical results.

Theoretically, torsion fields may be introduced by various methods [11, 12]. However, on the fundamental level they are introduced in a natural fashion within the framework of the Physical Vacuum concept [13]. To this end Einstein's equations:

$$R_{ik} - \tfrac{1}{2} R\, g_{ik} = k\, T_{ik} \qquad i, j, k.... = 0, 1, 2. 3$$

the Young-Mills equations:

$$F_{ij}^{A} + \partial_i B_j^{A} - \partial_j B_i^{A} - B_j^{A} B_j^{A} + B_j^{A} B_i^{A} = u J_{ij}^{A}$$

$$i, j, k.... = 0, 1, 2. 3 \qquad A, B ... = 0, 1 ... n$$

and Geisenberg's equations:

$$\gamma^{n} \frac{\partial \Psi}{\partial x^{n}} + 1^{2} \gamma_k \gamma_5 \Psi (\Psi * \gamma^{k} \gamma_5 \Psi) = 0$$

$$n, k.... = 0, 1, 2. 3$$

are written down in the spinor form and are completely geometricized:

•Geometricized equations of Geisenberg:

$$\nabla_{\beta\dot{\chi}} o_\alpha = \gamma o_\alpha o_\beta \bar{o}_{\dot{\chi}} - \alpha o_\alpha o_\beta \bar{i}_{\dot{\chi}} - \beta o_\alpha i_\beta \bar{o}_{\dot{\chi}} + \varepsilon o_\alpha i_\beta \bar{i}_{\dot{\chi}} -$$

$$- \tau i_\alpha o_\beta \bar{o}_{\dot{\chi}} + \rho i_\alpha o_\beta \bar{i}_{\dot{\chi}} + \sigma i_\alpha i_\beta \bar{o}_{\dot{\chi}} - \kappa i_\alpha i_\beta \bar{i}_{\dot{\chi}} ,$$

$$\nabla_{\beta_{\dot{\chi}}} i_\alpha = \nu o_\alpha o_\beta \bar{o}_{\dot{\chi}} - \lambda o_\alpha o_\beta \bar{i}_{\dot{\chi}} - \mu o_\alpha i_\beta \bar{o}_{\dot{\chi}} + \pi o_\alpha i_\beta \bar{i}_{\dot{\chi}} -$$

$$- \gamma i_\alpha o_\beta \bar{o}_{\dot{\chi}} + \alpha i_\alpha o_\beta \bar{i}_{\dot{\chi}} + \beta i_\alpha i_\beta \bar{o}_{\dot{\chi}} - \varepsilon i_\alpha i_\beta \bar{i}_{\dot{\chi}} .$$

$$\alpha, \beta = 0, 1, \qquad \dot{\chi}, \dot{\gamma} = \dot{0}, \dot{1}$$

•Geometricized equations of Einstein:

$$2\, \Phi_{AB\dot{C}\dot{D}} + \Lambda \varepsilon_{AB} \varepsilon_{\dot{C}\dot{D}} = \nu T_{A\dot{C}B\dot{D}} ,$$

•Geometricized equations of Young-Mills:

$$C_{A\dot{B}C\dot{D}} - \partial C\dot{D}\, T_{A\dot{B}} + \partial_{A\dot{B}} T_{C\dot{D}} + (T_{C\dot{D}})_A^{F} T_{F\dot{B}} + (T_{\dot{D}C})_{\dot{B}}^{\dot{F}} T_{A\dot{F}} -$$

$$(T_{A\dot{B}})^{F}_{C}\, T_{F\dot{D}} - (\bar{T}_{\dot{B}A})^{\dot{F}}_{\dot{D}}\, T_{C\dot{F}} - [T_{A\dot{B}}\,,\, T_{C\dot{D}}] = -\nu\, J_{A\dot{B}C\dot{D}}\,.$$

$$A, B \ldots = 0, 1, \qquad \dot{A}, \dot{B} = \dot{0}, \dot{1}$$

Concurrently, the mentioned system of equations represents in itself the Cartan structural equations of absolute parallelism geometry. The solutions satisfying this system of equations, as well as describing electromagnetic, gravitational and torsion fields, may be formed.

For a range of situations it is useful to interpret the fields, in a certain sense, as polarized conditions of the Physical Vacuum.

A number of preliminary points needs to be made. Let us consider the Physical Vacuum as a material medium isotropically filling out the entire expanse of space (both the free space and within substances), possessing a quantum structure and unobservable (on the average) in the unperturbed state. Such a vacuum is described by the operator <0| [52]. Different vacuum states occur as a result of the violation of the Vacuum's symmetry and invariance [14]. In specific cases, on examination of various physical processes and phenomena, the observer would normally make up models of the Physical Vacuum adequate to these processes and phenomena. The use of different models of the Physical Vacuum is characteristic of modern astrophysics in which, for instance, Θ-vacuum, the Urnu vacuum, the Bulwar vacuum, the Hartley-Hocking vacuum, the Rhindler vacuum, etc., are utilized as constructive models.

The updated interpretation of the Physical Vacuum treats it as a complex dynamic object that shows itself by way of fluctuations. The theoretical approach is based on the concepts of S. Weinberg, A. Salam and Sh. Gleshow.

However, as it will become apparent from further analysis, it has been admitted to be expedient to return to the P. Dirac electron-positron model of the Physical Vacuum in a somewhat altered interpretation of this model. At the same time, taking into account that the vacuum is defined as a state without particles, and proceeding from the classical spin model as an annular wave package [15] (a circulating energy flow, according to Belinfante's terminology [16]), we shall regard the Vacuum as a system consisting of annular wave packages of electrons and positrons, rather than made up by electron-positron pairs.

With these presumptions it is easy to see that the condition of genuine electroneutrality of the electron-positron vacuum will be complied with such a state when annular wave packages of electrons and positrons are inserted into each other. If the spins of these inserted annular packages are opposite at that, then the system will be self-compensated not only by charges, but by the classical spin and the magnetic moment. We shall call such a system of inserted annular wave packages a "phiton" (Fig. 1 A).

A dense package of phitons [17] will be considered as a simplified model of the Physical Vacuum (Fig. 1B). It is instructive to point out that in A. Krish's experiments [18] the observed effects are tantamount to demonstrating the possibility of realizing through dynamic but inserted states in the systems with opposite spins, just like in the presumed phiton model. We shall also point to yet another important circumstance confirming at least the admissibility of the phiton model. In conformity with the J. Bjorken model [19-21] we may set up electrodynamics without resorting to the notion of "photons" but based solely on the interacting electron-positron field. (This model is not devoid of a host of roadblocks). The concept of quantums of electron-positron pairs was employed by M. Broido [22] independently of J. Bjorken. Then, Ya. B. Zeldovich showed [23] that, with the presence of the electromagnetic field, the origination of electron-positron pairs takes place in the vacuum, as a result of which there appears a non-zero energy of the vacuum, regarded as the field energy. The connection of electromagnetism and vacuum fluctuations was marked by L.A. Rivlin [24]. Earlier similar ideas for the gravitational field had been formulated by A.D. Sakharov [25].

Formally, given the spin compensatedness of phitons, their reciprocal orientation in an ensemble in the Physical Vacuum may seemingly be random. However, it is visualized intuitively that the vacuum forms an orderly structure with a linear packing as is depicted in Fig. 1B. The idea of the vacuum's orderliness apparently belongs to A.D. Kirzhnitz and A.D. Linde. Let us consider the most significant of practical cases of agitating the Physical Vacuum with various external sources. It may possibly help evaluate the reality of the cultivated approach.

1. Let us assume that the charge *q* is the source of perturbation. In case the vacuum has a phiton structure, then the action of the charge will be denoted by the charge polarization of the Physical Vacuum as it is arbitrarily depicted in Fig. 1C. This case is well-known in quantum electrodynamics [26]. In particular, the Lambovsky shift is traditionally explained in terms of charge polarization of the electron-positron Physical Vacuum [27].

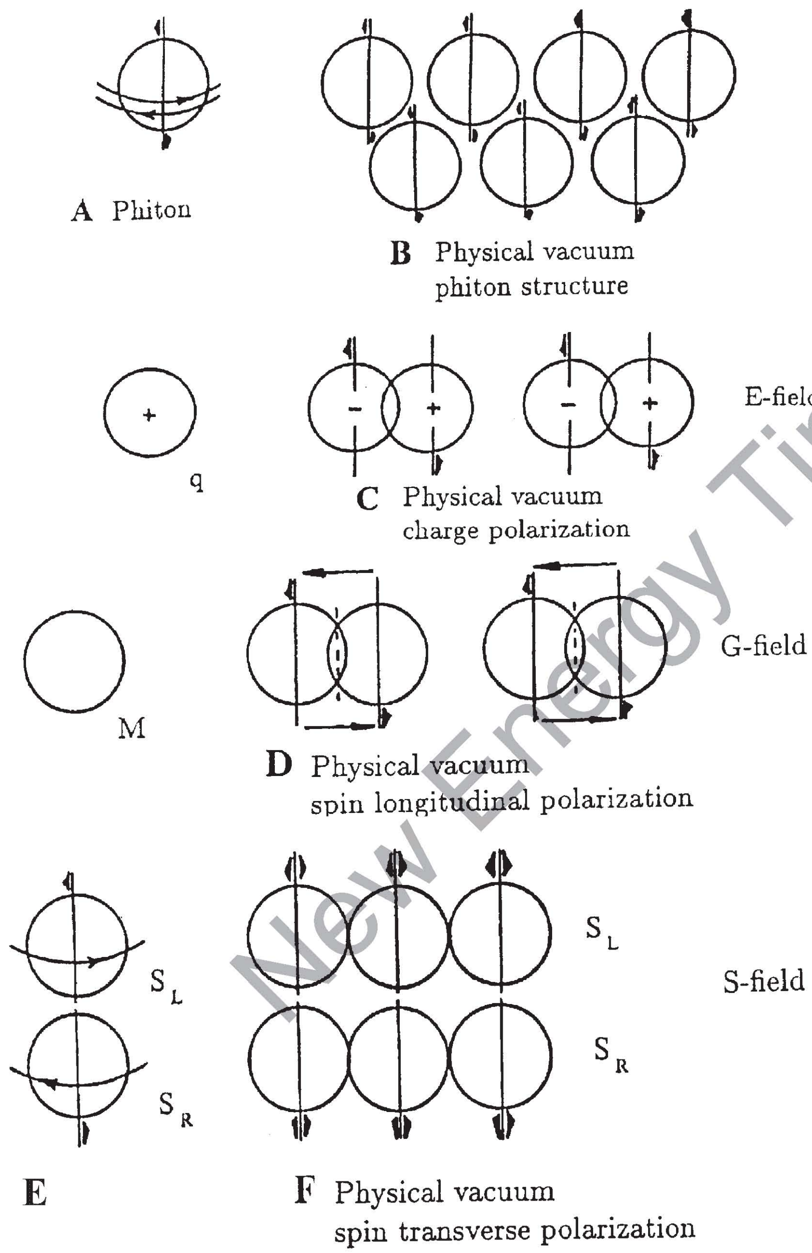


Fig. 1 Diagrams of the Physical Vacuum Polarized States

With regard to the already mentioned D. Bjerken model, Ya. B. Zeldovich's concepts [23], as well as [19], the state of the Physical Vacuum charge polarization may be interpreted as an electromagnetic field (E-field).

2. Let the mass - *m* be the source of perturbation. The perturbation of the Physical Vacuum by the mass m will be expressed in the symmetric oscillations of phiton elements along the axis to the center of the object of perturbation, as it is schematically shown in Fig. 1D. Such state of the

Physical Vacuum may be characterized as a spin longitudinal polarization interpreted as a gravitational field (G-field). As has already been noted, A.D. Sakharov introduced the concept of the gravitational field as the state of the Physical Vacuum [25], and this complies with the stated gravitation model. The polarization states of gravitation were discussed in [28].

The dynamic longitudinal polarization conforms with the property of nonscreenability of the gravitational field. V.A. Bunin [29], and at a later time V.A. Doubrovsky [30], without considering gravitation mechanism, yet supposing that gravitational waves were the longitudinal waves in the resilient Physical Vacuum, demonstrated that the velocity of such waves ia on the order of $10^9 \bullet c$.

Theories related to superlight velocities are usually not considered in physics. This is connected with the fact that in such cases thought experiments lead to the violation of the causality links. It may be feasible, however, that in a higher level of cognizance the "superlight catastrophe" will be overcome the same way as the "ultraviolet catastrophe" had previously been overcome.

The suggested approach to the interpretation of the gravitational mechanism is in no way exotic. Gravitational field in the induced gravitation theories [31] is viewed as a consequence of Vacuum's decompensation that arises with its polarization [23, 25, 32]. In the research work of Boutorin [33, 34], as well as those of Bershadsky and Mekhed'kin [35, 36], estimates of the frequencies of oscillation peculiar to gravitation were obtained. But the spread of these estimates is very great and amounts to 10^9 - 10^{40} Hz. There are grounds to assume that the frequency span extending from 10^{20} - 10^{40} Hz is more likely.

Should the mechanism of gravitation be really connected with the longitudinal spin polarization of the Physical Vacuum, then in this case, it will have to be acknowledged that the nature of gravitation is such that antigravitation does not exist.

3. Let the classical spin - *s* be the source of perturbation. We shall conjecture that the impact of the classical spin on the Physical Vacuum will consist of the following. Granted the source has a spin oriented as is indicated in Fig. 1E, then the spins of the phitons that match the orientation of the source spin will retain their orientation. Those phiton spins that are opposite to the source spin will experience inversion under the effect of the source. As a result, the Physical Vacuum will transform into the state of a transverse spin polarization. This polarized state can be interpreted as a spin field (S-field), i.e., a field generated by the classical spin. The formulated approach is in agreement with the ideas of spin fields as a condensate of fermion pairs [37].

Spin polarization states S_R and S_L contradict the Pauli prohibition. However, according to the concept of M.A. Markov [38], under certain quantum mechanical conditions [28, 29], fundamental physics laws may have another aspect, different from the familiar ones. A waiver of the Pauli prohibition for such a specific material medium as the Physical Vacuum is admissable, perhaps, in no lesser degree than in the quarks concept.

In congruity with the above stated approach, it may be said that a unified medium - the Physical Vacuum - can exist in different phase (to be exact, polarization) states, EGS-states. In the state of charge polarization the given medium manifests itself as an electromagnetic field (E). The very same medium, while in the state of spin longitudinal polarization, shows itself as a gravitation field (G). Finally, the same medium (the Physical Vacuum) in the state of spin transverse polarization displays itself as a spin (torsion) field (S). All told, EGS-fields correspond to EGS-polarization states of the Physical Vacuum.

All three fields, generated by independent kinematic parameters, are universal or, in the terminology of R. Outiyama, they are fields of the first class: these fields display themselves both on the micro- and macroscopic levels. It is pertinent to recall the words of Ya. I. Pomeranchuk: "The entire physics is the physics of the vacuum." The development of the concept allows for an approach to the problem – at least the problem of universal fields – from some general standpoints. In the suggested model the role of the unified field is played by the Physical Vacuum, the polarization (phase) states of which manifest as EGS-fields. Modern nature does not need any "unifications." There is but vacuum and its polarized states existing in nature, whereas the "unifications" only reflect the degree of our understanding of fields' interconnection.

The notion of the phase state of the Physical Vacuum and the polarized states of the Physical Vacuum was being used in its general form in many works (see, for instance, [40]). It was repeatedly noted in the past that the classic field might be viewed as a state of the vacuum [23, 25]. However, polarized states of the Physical Vacuum were not lent the fundamental role such states were actually playing. Normally, the question of which Vacuum polarizations were borne in mind would not be discussed. In the listed approach, the polarization of the vacuum in accordance with Ya. B. Zeldovich [23] is interpreted as a charge polarization (electromagnetic field). The Vacuum polarization is interpreted by A.D. Sakharov [25] as a spin longitudinal polarization (gravitational field). The polarization for the torsion fields is interpreted as a spin transverse polarization.

Torsion fields have properties that differ substantially from known properties of electromagnetism and gravitation. The most critical properties of torsion fields (emissions) are the following:

1. Unlike electromagnetism where analogous charges are repelled while those of the opposite ones are attracted, in torsion fields similar charges get drawn to one another and opposite charges are repulsed.

2. As torsion fields are generated by a classic spin, so, as a result of the torsion field effect on a certain object, only the spin state of the given object will change.

3. The emissions are non-dissapative, non-interacting in their transmission through physical media. It is worth pointing out that beyond any connection **with torsion fields that Soviet physicists had demonstrated more than ten years ago, that spin signals were spreading in a fashion that prevents their being screened.**

4. The group velocity of torsion waves is no less than $10^9 \cdot c$. In the Russian journal, *Achievements of Physics Sciences*, a vast survey was published with the analysis of astrophysical objects traveling at the velocities exceeding the speed of light [53]. **The absence of losses during the torsion waves' spreading makes possible long-distance communication with the use of low power at transmission**. There is the possibility of submarine and subterranean communication. High group velocity of torsion waves removes the problem of signal retardation even within the bounds of the Galaxy.

5. Since all known substances possess a non-zero collective spin, then all substances possess their own torsion field. The expanse and frequency structure of the torsion field of any substance is determined by the chemical composition and the expanse structure of the molecules or the crystallized lattice of the substance.

6. Torsion fields are endowed with memory. A torsion source of a definite expanse and frequency torsion field structure polarizes (by a classic spin) the Physical Vacuum in a certain space surrounding it. At that, the emerging space spin structure is retained after the torsion source moves to another area of space. The paradigm of torsion fields has made it possible to acquire important new results in practically all scientific and technological disciplines.

TORSION SOURCES OF ENERGY

Over the course of the last 20 years many authors have pointed out to the potential possibility of deriving energy from the Physical Vacuum. References to the necessity of creating anomalously high intensity electric fields (on the order of 10^{16} V/cm) render conventional objections against the practical plausibility of obtaining polarized effects in the Physical Vacuum.

These objections would undoubtedly be fair if it concerned charge polarized states. But we are tackling spin polarization of the Physical Vacuum with no electromagnetic nature whatsoever. Space-steady torsion polarized states are observed experimentally. The possibility of an effective interaction of spin (rotating, spinning) objects with the Physical Vacuum enables us to consider from a fresh standpoint the feasibility of creating torsion sources of energy.

The traditional attitude boils down to the assertion that, since the Physical Vacuum is a system of minimal energy, no energy can be derived out of such a system. At the same time, however, it is not taken into account that **the Physical Vacuum is a dynamic system having intense fluctuations which may be exactly the source of energy.** It is useful to point out the contemplations of Ya. B. Zeldovich, A.D. Dolgov and M.V. Sazhin [25], who, while writing down the conditions for the vacuum $a_k \mid vac\rangle = 0$ as a reflection of the state without particles, found that the value of vacuum energy was equal to $\langle vac \mid H_k \mid vac\rangle = w_k/2$. As the authors noted, this infinite energy had been ignored, declared unobservable and the particles' energy had not been evaluated as infinite.

By considering the vacuum as a combination of non-interacting oscillators with the frequencies w_k, the Hamiltonian may be written as follows:

$$H_q = \sum_\kappa \omega_\kappa (\alpha_\kappa^+ \alpha_\kappa + \frac{1}{2}) \ ,$$

in which operators α_κ^+ and α_k are as usual operators of origin and elimination. Then the vacuum, as the lowest-of-all energy state, has a non-zero energy density

$$\varepsilon_o = \frac{1}{2} \frac{4\pi}{(2\pi)^3} \int \kappa^2 \omega_\kappa d\kappa.$$

However, in reality it is fairly simple to build up a numerical assessment of this density. According to J. Wheeler [39], this estimate is given by the Planck density of the energy

$$\hbar c / L^4 \rightarrow c^5 / \hbar G \sim 10^{95} g/cm^3 \ .$$

In comparison with the density of the nuclear substance (-10^{14}g / Cm^3), the density of the energy connected with vacuum fluctuations stands out as quite an impressive value. Other evaluations of vacuum fluctuation energy are known as well, but all of them are considerably larger than the estimates of J. Wheeler.

We shall emphasize two conclusions:

1. The energy of vacuum fluctuations is very great compared to any other type of energy;

2. The infinitesimal torsion energy required for the spin polarization of the Physical Vacuum offers hope that, by virtue of torsion perturbations, it will become possible to release the energy of vacuum

fluctuations. From these premises the experimental results that have been yielded in the recent decades by Moore, King, Nieper and others, representing some sort of a traditional science periphery and registering the efficiency of up to 300 - 500% [50, 51], do not look inadmissibly outrageous. Their systems with a spinning (typically torsion installations), as open systems at the expense of a weak interaction with the vacuum, drew from the vacuum no more than a mite of energy. Apparently the said theoretical ponderings alongside the mentioned experimental results are but a gleam of daylight glimmering through a cracked open doorway to the energetics of the oncoming century. This energetics is ecologically pure and does not require the expenditure of either combustibles or any other substance.

TORSION PROPELLERS

New concepts of fields and forces of inertia stated in the work [13] allow us to see a connection with torsion fields and predict the existence in nature of a new class of reading systems which were named [13] secondary type accelerated local and Lorentz readout systems. As distinguished from primary accelerated local and Lorentz systems, introduced by A. Einstein, the new systems are formed in cases where the center of mass of the isolated system is affected by the compensated forces of inertia.

A system connected with the center of mass of a spinning gyroscope serves as a plain example of an accelerated Lorentz readout system. Really, compensated centrifugal forces of inertia affect the center of mass of the free-rotating gyro, that is why such gyro's mass center rests or moves rectilinearly and steadily in relation to the inertial system of observation. If by any tool the balance of inertial forces in the gyroscope becomes upset, then the gyroscope's center of mass will accelerate under the influence of the internal uncompensated forces.

This inference does not contradict the noted theorem of the conservation of the center of mass momentum of an isolated mechanical system. In compliance with the theorem, internal forces of an isolated system cannot alter the momentum of its mass center, based on the following axioms:

1. Internal forces satisfy Newton's third law;

2. Internal forces are all of those forces that operate in the inner volume, confined to the partitions of an isolated system.

Most of the forces of the classic mechanics answer the first condition and may be divided into the outer and inner ones in accordance with the second stipulation. However, there exist in the mechanics such forces which fail to satisfy the third law of Newton. Such are the forces of inertia, since one cannot say from the side of which bodies these forces are applied. More than that, the forces of inertia do not fall within the second condition, as they are at the same time both the internal and the external ones for the isolated (in the sense defined above) mechanical system.

Hence, the movement of mechanical systems affected by the internal uncompensated forces of inertia is not at variance with the theorem of the conservation of the center of mass momentum for the isolated system of Newtonian mechanics, because the forces of inertia fail to satisfy the conditions under which this theorem has been proven.

As an illustration of a mechanical system (the center of mass which moves under the effect of the uncompensated forces of inertia) a device is offered that demonstrates the link between the forward and the rotary forces of inertia, which may be called a four-dimensional gyroscope. It consists of the central mass M and two masses m, rotating simultaneously toward each other around the axis fixed to the central mass M (see Fig. 2). If at some moment of time this system is furnished with mechanical energy (for instance, by way of rotating masses *m*), it will come into motion and we shall have the following equation of motion [13]:

$$(M + 2m)\,\ddot{x}_c = (M + 2m)\,\ddot{x} - 2mr\dot{\omega}\sin\phi - 2mr\omega^2\cos\phi$$

$$J\,\dot{\omega} - J\kappa^2\,\frac{\sin\phi\cos\phi}{1 - \kappa^2\sin^2\phi}\,\omega^2 = 0$$

where notations are introduced

$$\kappa^2 = B/r\,, \qquad B = \frac{2mr}{M + 2m}$$

This mechanical system has been named a four-dimensional gyroscope because, in the motion equation (1), the rotation takes place at the space angle ϕ and at the space/time angle θ, connected with the forward acceleration of the system $W = x$ by the correlation $W = x = V_x = c\frac{d}{dt}$ *(tan* θ*), tan* θ = $\frac{dx}{cdt}$ where *c* = the velocity of light.

It is seen from Fig. 2 that the reading system, connected with the center of mass of the four-dimensional gyroscope, turns out to be the secondary locally accelerated Lorentz readout system. It is possible to disturb the balance of inertial forces in this system by two methods:
a. either by means of affecting it with the external force F_e (the problem of interaction); or
b. by putting effect on the axis of smaller loads rotating with the internal moment M_o (the problem of self-action).

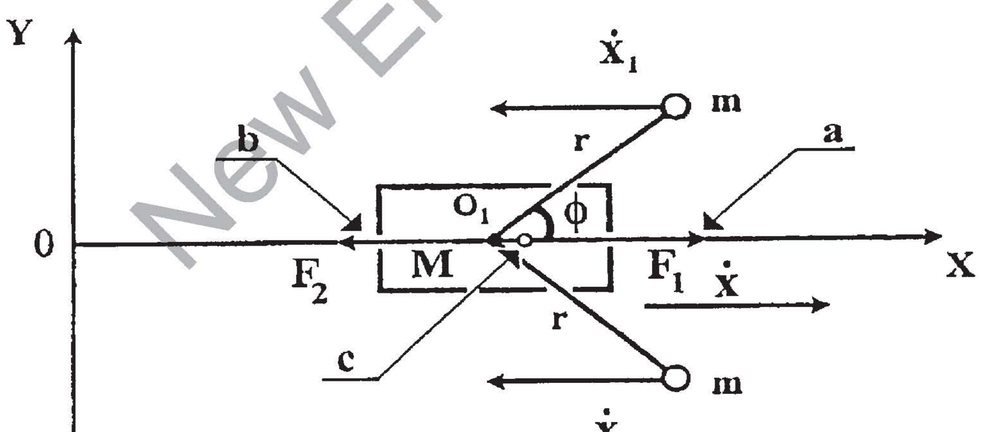


Fig. 2 a) The forward force of inertia $F_1 = (M + 2m)\ddot{x}$;
b) The sum of the rotation forces of inertia $F_2 = -2mr\omega^2\cos\phi - 2\,mr\dot{\omega}$

The four-dimensional gyroscope with self-action was accomplished, perhaps, practically for the first time ever by the Russian engineer Vladimir Nikolayevich Tolehin [48] and was named by the inventor an inertioid. As chief designer of the Perm mechanical-engineering plant, V.N .Tolchin manufactured inertioids of various types, a series of properties of which is listed in his book [48]. From the point of view of its design, the Tolchin inertioid is realized in such a fashion that for the sake of regulating the velocity of its center of mass, there is a device called a motor-brake. The designation of this apparatus is to perform the self-action of the inertioid in the sectors of 330° - 360° and 160° - 180°. An increase of the center of mass velocity from 0 up to the value of around 10 cm/sec took place in the 330° - 360° sector, while in the sector of 160° - 180° a decrease of the center of mass velocity from 10 cm/sec down to 0 took effect.

The experiments undertaken by V.N. Tolchin point to the reality of the existence of a new class of accelerated readout systems – the second type accelerated local and Lorentz systems. They bear a promising feature and will permit the creaton of a new type of propeller in the future.

TORSION TECHNOLOGIES FOR MATERIALS PRODUCTION

It is common knowledge that with the cooling off of a melt, the solid phase of a substance (for instance, a metal) is realized via two processes. The ions in the melt must occupy their places in potential wells that correspond to the joints of a solid body's crystalline lattice, and the spins of the ions (atoms) must be oriented by the ribs of the lattice as it is prescribed by the type of the crystalline lattice. The latter circumstance is ordinarily used to explain dia-, para- and ferro-magnetism. The non-execution of any of these two conditions results in the structure of the solid matter being different from the natural one, which is prescribed by the traditional laws of solid-body physics.

As a result of an external torsion field (emission) effect on the melt, for example, by the torsion generator, only the spin state of the system of free atoms in the melt will undergo a change. In case an isotropic torsion radiation affects the melt of solid matter, then, given sufficient time of exposure and adequately established parameters of the melt, all atoms of the melt will pass into the state of a unidirectional orientation of spins. In such a state the atoms, by virtue of spin-torsion interactions, will experience mutual gravity. At the expense of this reciprocal torsion attraction, the melt, as a spin system, will be internally stable. As a result, the strong mutual gravity, even during a slow cooling-off, will not allow the atoms to orient their spins along the ribs of the crystalline lattice and the lattice will not be realized. Its consequence will manifest itself in an amorphous structure of the substance (metal), a structure of a quasi-glass.

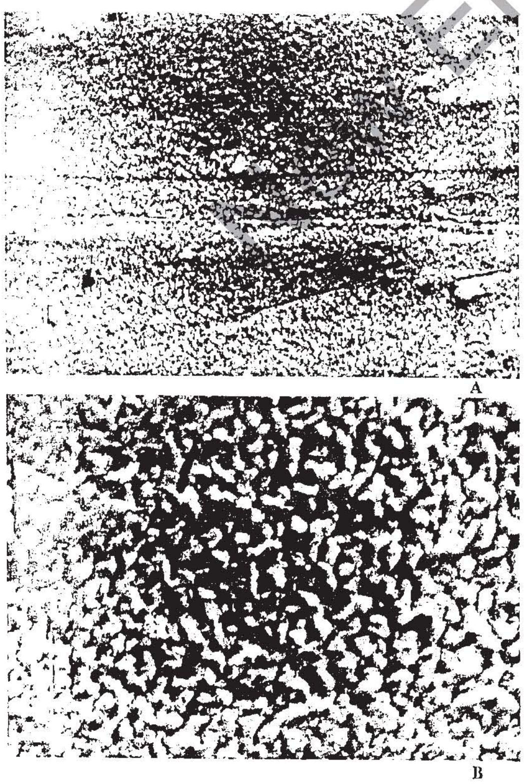


Fig. 3 A cross-section view of tin A in control (x6000) and a picture of a section of tin B after treating the melt with a torsion field.

Under the influence of the torsion radiation with a non-isotropic space-frequency structure on the melt, provided that the above mentioned conditions are met: either crystallization occurs, but with a crystalline lattice "induced" in the substance by the established structure of the external torsion field, or torsion-induced defects of the crystalline lattice will occur.

All listed variants of theoretically predicted results of the torsion field effect on the melt of the metals were experimentally confirmed in the Ukraine Academy of Sciences Institute of Materials Technology in the works carried out from 1989 to 1993.

A photo picture of a tin cross-sectional slide, in Fig. 3, shows it after a check smelting (Fig. 3A) and in the wake of smelting after affecting the melt with the torsion radiation at the 8 Hz frequency (Fig. 3B). It is easy to see that the metal treated in the melt has larger grains, almost identical in sizes. The structure of the metal is isotropic in volume. The research attested that the grains lacked their ordinary complete crystalline lattice, forming a highly dispersed state [41] close to the absolute amorphization.

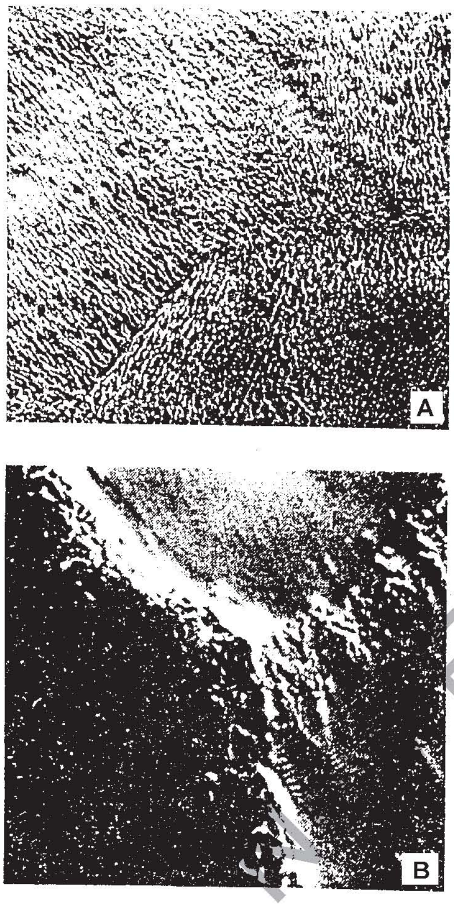


Fig. 4 Cast copper microstructure: A - in control (x100), B - produced after being rayed by the torsion field (x100).

In other series of experiments with copper [42], the alteration of grains structure was observed (Fig. 4A,B), as well as the appearance of twins as a result of the torsion effect on the copper melt (Fig. 5A, B). In the period of 1994 to 1995 the change in the structure and physical-chemical properties of metals was demonstrated at the plants smelting furnaces.

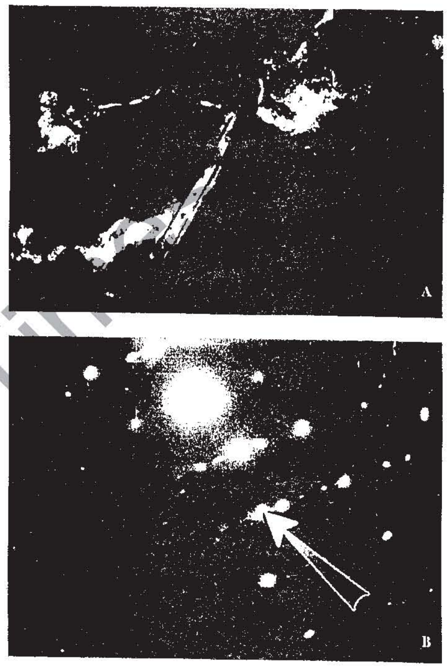


Fig. 5 A dimmed-field picture of the double in the reflex A, indicated by arrow in the electronogram B (A-x19000)

The theoretic prediction of the impossibility to screen torsion fields by means of conventional materials was displayed in the example of torsion influence on metal melts in the grounded all-metal Tamman furnaces. The predicted information, not an energy character of torsion effects, was confirmed in the works when the structural rearrangement of steel in the amount of 200 kg was achieved by a torsion generator consuming 10 mW of electric power,

TORSION MEANS OF COMMUNICATIONS AND INFORMATION TRANSMISSION

In the customary means of radio communication, impressive amounts of power are necessary to compensate for the attenuation of signals during the passage of signals in open space due to their attenuation by the inverse square law, $\frac{1}{r^2}$, as well as to make up for the losses incurred due to the absorbing media that the signals pass through.

At the same time, the compensation should be fulfilled to such a degree that a transmitted signal at the input of the receiver has an intensity exceeding the sensibility of that very receiver. Besides, given the speed of the radio signals' passage, a signal delay already in the satellite communications systems will cause trouble. These setbacks develop into major problems for communicating with spacecraft in the far-out reaches of the cosmos.

The difficulties with the beyond-horizon communications lead to the necessity of setting up sophisticated global communications networks complete with retransmitters. In specific cases, radio communication may be carried out not only in the sphere of ultralong waves but, for instance, for a subterranean connection. However, the speed of information relay is dissipated, to say nothing of apparent technical problems accompanying such transmission.

A range of radio communication problems is insoluble in principle. This is, for example, communication with the returning space modules and orbiters as they are screened by plasma upon entering the dense layers of the atmosphere.

All the stipulated communication problems are negotiated with the application of torsion communication [43]. It will suffice to point to the three abovementioned properties of torsion radiation: torsion emissions neither weaken with distance nor are absorbed by natural media and they have a group velocity no less than $10^9 \bullet c$.

As torsion signals neither fade away with distance nor get absorbed, there is no need in employing big power capacities for transmitters, even along lengthy routes. For lack of absorption by natural media, torsion signals provide both subterranean and submarine communication, as well as through a plasma-permeated space. With such a high group velocity it is feasible to solve communications, control, and navigation problems on a real time scale, not only within the bounds of the solar system but even in the limbo of the galaxy itself. The first experiments in transmitting binary signals along the torsion channel of communication were held in April 1986 in Moscow. A torsion transmitter was installed in the ground floor of a building where there were no devices like a radio antenna and no need to mount the transmitter on the roof. A torsion receiver was placed in the first floor of another edifice at the distance of about 22 km (Fig. 6). In such a setup the torsion signal could travel only along the straight line: from the transmitter to the receiver.

This signified that apart from clearing the local relief, the torsion signal, considering the density of Moscow housing development, had to negotiate a screen equivalent to a ferroconcrete wall as thick as 50 meters. That was practically an impossible task for radio communication devoid of the retransmitters.

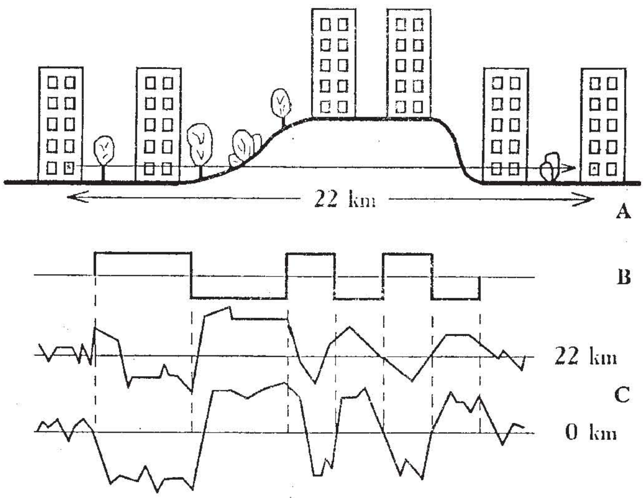


Fig. 6 An illustration of binary torsion signals transmittal. Scheme of track A, type of transmitted signals B and type of received signals C.

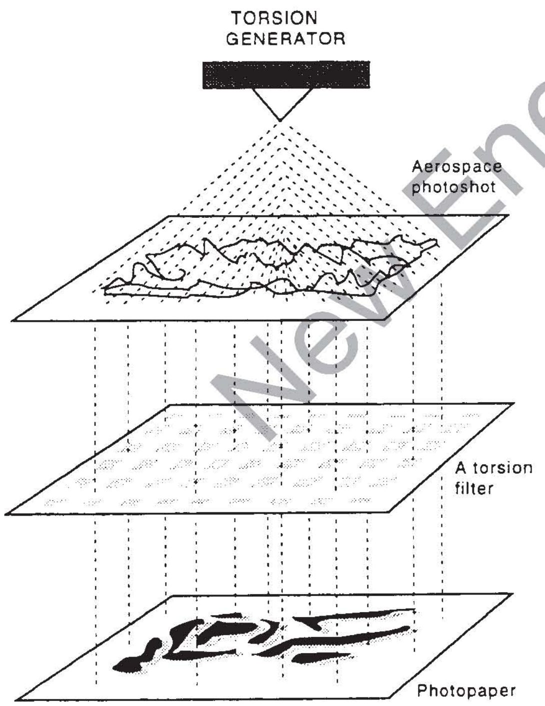
In the performed communication hook-ups, the binary torsion signal of the start/stop telegraphic code M2 was received flawlessly, with the torsion transmitter consuming the energy of 30 mW. During the additional experiments, the torsion transmitter was brought back to the receiver (a zero-length track). In that case, the intensity of the registered signal would not change. The described assay proved that in a torsion communication, as the theory had prognosticated, the torsion signal does not become absorbed, nor does it get diminished with distance.

TORSION GEOPHYSICS

As has already been pointed out on the fundamental level, the nature of torsion fields is attributed to the classic spin. Two consequential effects may be derived:

First, since atoms in all molecules and all crystals have not only a definite space position but a strictly specific reciprocal orientation of spins, all molecules and all crystals have a torsion field of their own with a characteristic space/frequency distribution of intensity (space and frequency spectrum). A great amount of homogeneous matter will create a collective characteristic (for the given substance) torsion field. Keeping in mind that torsion fields are not absorbed by natural media and their intensity is not attenuated by distance, the locally concentrated homogeneous substance, situated at a random depth in the Planet, will be creating outside the planet an identical characteristic torsion field, as if that substance were situated on the surface of the planet. That is why, by registering a space/frequency structure of the Planet's torsion fields valuable data on the planetary internal structure may be retrieved.

Second, the development of the trends in the fields as polarized (phase) states of the Physical Vacuum [1] made it possible to define the torsion field as a state of spin transverse polarization of the Physical Vacuum. Alongside other theoretical factors, this served as a basis to suppose that by registering space and frequency structure of the torsion field, the Planet or a part of its surface, (i.e., the space structure of spin polarized states), one can obtain critical data on the Planet's internal macroscopic structure.



A structural scheme of a torsion processing of aerospace pictures. After a paper by A.E. Akimov and G.I. Shipov

Fig. 7

Fig. 7

It became possible to confirm experimentally the validity of the hypothesis that in the process of photographing any objects, these very objects' own torsion fields, while impacting the photo emulsion together with the light, alter the bearings of emulsion atoms spins, so that emulsion spins copy the space structure of this external torsion field. As a result, there always exists alongside any visible photo image an invisible torsion picture. The awareness of this fact by analogy with the optical treatment of images allowed us to build up a procedure of extracting torsion images from the photographs and their processing [44]. As it is depicted in Fig. 7, first of all a slide or a photo gets exposed to the isotropic wide-band torsion emissions beamed by the generator of such radiation . In this case the spin structure of the emulsion atoms may be viewed as a two dimensional spin matrix that plays the role of a diametric spin modulator.

After the isotropic torsion radiation penetrates the initial picture, the modulated torsion emission will be copying the spin structure of the space torsion field which has been taken by the emulsion during the photographing. However, this initial torsion field represents, in itself, a superposition of torsion fields from all the sources in the crust of the Planet. Geological formations or mineral deposits may be among such sources. Since these structural formations have characteristic space and frequency spectra, then, if the problem lies in extracting the zone of some substance concentration (a mineral deposit), the modulated torsion radiation should be subjected to a respective filtration. For this purpose two-dimensional spin matrixes spin filters have been devised. Such spin (torsion) filters transude only those space frequencies that correspond to the characteristic space frequencies of the torsion emissions of the desired substance.

After the passage through the torsion filter, torsion radiation will be present only in those places relative to the initial photo where the substance sought is situated. This useful torsion component filtered radiation is directed to the special pure photo material subjected to a special physical and chemical exposure which provides an opportunity for the photo registration of torsion emissions.

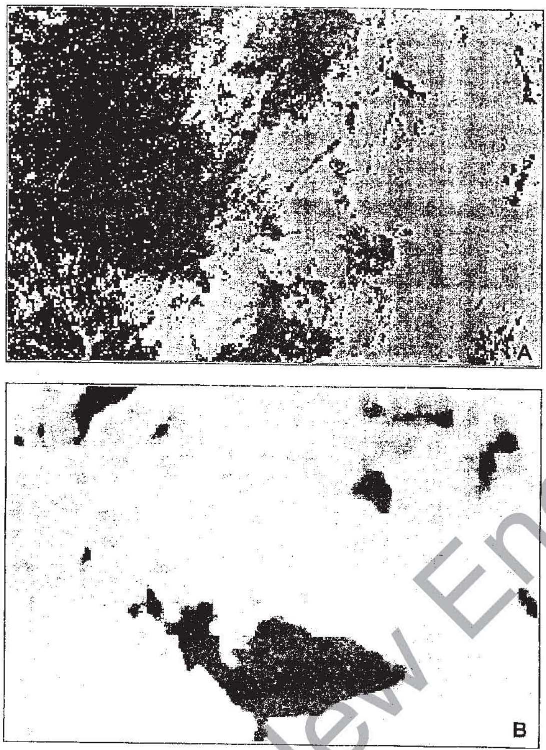


Fig. 8 An example of a torsion treatment of space photos: A - an original space IR-picture; B - a torsion treatment result.

Besides the forenamed functional possibility of extracting information on the internal structure of different cosmic bodies and objects or on the presence of various mineral deposits on the Planets and their satellites, the physical processing apparatus complex allows extraction of integral torsion data from the photo pictures, using a torsion filter is not utilized (Fig. 7).

In Fig. 8 to illustrate such processing, a segment of the Earth's surface is shown in the IR-photo (Fig. 8A) and the view of this segment after the torsion treatment (Fig. 8B), where the structure of the geophysical heterogeneity is distinctly visible.

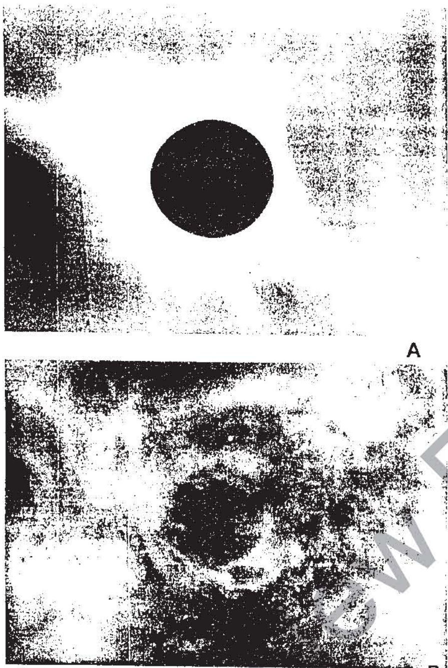
It is not incidental that in the given section the term "Earth" has been used alongside that of "Planet." It is explicitly obvious that the developed physical methods, means, and related technologies are of major significance to the physics of planets, not to mention the physics of the Earth. More than that, it may be asserted that for, say, the planets of the Solar system and their satellites the itemized methods are all the more important, for, as distinguished from the Earth, there is so far no possibility of using the entire arsenal of traditional geophysical methods for the sake of the global study of the subsurface structure of the planets and their satellites in spite of the fact that a lot of photo prints of planets and their satellites is on hand. The work in this direction is being carried out already,

TORSION ASTROPHYSICS

The methods of extracting and processing torsion information, reported in the preceding section, enable us to cast a fresh glance at the content and potentialities of astrophysics.

The entire modern observational astrophysics and astronomy have been using their opportunity to handle exclusively visible objects ("visible" in the broad sense of the word, including, for instance, radio observations). Bearing in mind that light may travel from remote sources as far as thousands of light years while in the mean time the stars undergo enormous shifts in space, it becomes apparent that modern astronomy is in fact not current in the very sense of the word, but a paleoastronomy (we investigate what has long been gone). Let us take into account the superlight velocity of torsion waves and note that all stars rotate, that is, they are torsion sources. By registering their torsion emissions it is possible to acquire the veritable celestial placement of stars and their position in the real time of the Universe. The first experimental results of stars fixation as to their authentic position were produced by N.A. Kozyrev [45] and later by M. M. Lavrentjev, I.A. Yeganova [46] and A.F. Pougatch [47].

The second important problem of astrophysics is the following discrepancy. If we proceed from the existence of only two long-range actions – electromagnetism and gravitation – in which the velocity of waves cannot exceed "c", then the time of the interaction between the fringes of the observed Universe will be in proportion to the life tenure of the Universe. Then, it must be admitted that most of the far-outlying objects of the Universe do not interact, i.e., the Universe cannot be considered as an integral system of internally interconnected objects (this circumstance was first pointed to by A.A. Silin).


A

B

Fig. 9. A picture of the Sun -A and its torsion protrait image - B.

At the same time it has been known for many decades that stars form a cellular structure, that is to say, there is a physical interaction which keeps the Universe in a kind of an interacting and steady structure. It may be that, possessing the velocity on the order of $10^9 \cdot c$, the very torsion fields of the stars provide the origin and existence of the cellular structure in the distribution of stars in the Universe. We should not shun the possibility that the problem of "concealed mass" is in reality a consequence of the fact that torsion interactions are not taken into account. In this preliminary analysis we shall point out yet another noteworthy circumstance. Since in the course of the torsion processing of space prints, it is possible to receive the images of our planet's inner structure, it is feasible to obtain data on the inner structure and inner dynamics of stars, e.g. the Sun, by way of carrying out such picture processing. Fig. 9 displays a picture of the Sun (Fig. 9A) and the results of its torsion processing (Fig. 9B) revealing global non-uniformities inside the Sun. Such approach opens up an essentially new option in the observation of astrophysical objects.

Finally, there is one more fundamentally novel possibility. In standard observations, with the exception of areas of nebulae, outer space looks "isotropically void". However, just as predicted by the theory, data on large-scale cosmic space structure and the Physical Vacuum large-scale structure may

Fig. 10 A torsion processing of the perisolar space photograph.

become available by virtue of the Physical Vacuum spin states, i.e., via the torsion fields of free space.

Fig. 10 depicts cosmic space having the size amounting to over thirty Solar diameters. A picture filmed during the Solar eclipse was subjected to a torsion processing. After the torsion processing of this photo, in accordance with the methodology described in the previous section but without a special spin filtration, this image was produced characterizing the Physical Vacuum global structure in such a vast cosmic expanse.

There are grounds to surmise that such prints are an experimental confirmation of the correctness of the hypothesis advanced by V.A. Ablekov, as well as D. Bohm and K. Pribram, in compliance with which the Physical Vacuum possesses the property of a hologram. Really, in Fig. 9B the boundaries corresponding to the boundaries of the initial picture are shown, whereas the torsion image was received far beyond these boundaries.

CONCLUSIONS

Not only theoretical but also numerous experimental results testify to the fact that torsion fields are an emphatic reality of nature. Aforementioned evidence reflects but a mite of the accomplished large-scale research work involving half a hundred scientific establishments. The acquired results considerably change our ideas of the organization of the world. This indicates that the formulated scientific concepts form a new scientific Paradigm which is probably destined to play a more critical role than the breakthrough in physics of the closing 19th century. The already achieved results prompt a conclusion that 21st century technologies will be torsion technologies.

Preprint No. 4. The Natural Sciences Academy International Institute for Theoretical and Applied Physics, Moscow, 1995, 33 .

REFERENCES

1. Akimov A.E, "An Heuristic Discussion of an Issue of a Discovery of New Long Distance Interactions," *EGS- Concepts.* MNTC VENT, pre-print N7A, p 63, in Russian.
2. H. Tetrode, "Uber den Weikungszusammenhang der Welt. Ein Erweiterrung der Classischen Dynamik," *Zeit. fur Physic,* 1922, vol 58, p 317.
3. A.D. Fokker, "Ein invarianter Variationssatz fur die Bewegung mehrerer electricher Massenteilchen," *Zeit. fur Physic,* 1929, vol 58, p 368.
4. J.A. Wheeler, R.P. Feynman, *Rev. Mod. Phys.*, 1945, vol 17, no 1, p 157.
5. J.A. Wheeler, R.P. Feynman, *Rev. Mod. Phys.*, 1949, vol 21, no 3, p 425.
6. F.W. Hehl, " Spin and Torsion in General Relativity," *I. Foundations, GRG*, 1973, no 4, p 333.
7. F.W. Hehl, P. Heyde, G.D. Kerlick, J.M. Nester, "General Relativity with Spin and Torsion: Foundations and Prospects," *Rev. Mod. Phys.*, 1976, no 3, p 393.
8. F.W. Hehl, "On the Kinematics of the Torsion Space-Time," *Found. Phys.*, 1985, vol 15, no 4, p 451.
9. T.W.B. Kibble, "Lorentz Invariance and the Gravitational Field," *J. Math. Phys.*, 1961, no 2, p 212.
10. D.W. Sciama, "The Physical Structure of General Relativity," *Rev. Mod. Phys.*, 1964, no 36, p 463.
11. A.P. Ephremov, "Space-time spinning and torsion field effects," *Analytical review*, MNTC VENT, Moscow, 1991., p 76, in Russian.
12. V.E. Bagrov, A.A. Evseyevitch, A.V. Shapovalov, "A Symmetry, Variables Division and Exact Solutions of the Diraque Equation in Riman-Karatan's Space," *Tomsk*, Tomsk's SC SO AS USSR, 1989, pre-print N 51, p 31, in Russian.
13. Shipov G.I., Theory of Physical Vacuum. Moscow; NT-Center, 1993, c. 362, in Russian.
14. A.A. Grib, E.V. Dumansky, V.M. Maximov, "Issue of a Symmetry Violation and Vacuum Invariance in the Quantum Field Theory," *UFN*, 1970, vol 102, no 4, p 587, in Russian.
15. H. Oganian, "What is a spin?," *1988 Foreign Physics*, Ser. B, Mir, Moscow, 1988, p 68, in Russian.
16. F.J. Belinfante, "On the Spin Angular Momentum of Mesons," *Physics VI*, 1939, vol 6, no 9, p 887.

17. A.E. Akimov, V.V. Boytchuk, B.Y. Tarasenko, "Long-acting spin fields," *Physic Models*, AS UkSR, IPM, Kiev, 1989, pre-print N 4, p 23 (see also A.E. Akimov, V.Y. Tarasenko, "Models of Polarization States of Physical Vacuum and Torsion Fields," *EGS-concept*. MNTC VENT, 1991, pre-print N 7, p 31, in Russian).
18. Alan. D. Krish, "Collision of Rotating Protons," *Life of Science*, 1987, no 10, p 12, in Russian.
19. I. Bialynicky-Birula, "Quantum Electrodynamics Without Electromagnetic Field," *Phys. Rev.*, 1963, no 130, p 465.
20. J.D. Bjorken, "A Dynamical Origin for the Electromagnetic Field," *Ann. Phys.*, 1963, no 24, p 174.
21. J.D. Bierken, S.D. Drell, Relativistic Quantum Theory, Science, Moscow, 1978. p 295, in Russian.
22. M.M. Broido, *Phys. Rev.*, 1967, vol 157, no 144.
23. Y.B. Zeldovitch, "Interpretation of the Electra-Dynamics as Derivative of Quantum Theory," *Letters to ZETF*, 1967, vol 6, no 10, p 922, in Russian.
24. L.A. Rivlin, "Energy of Wave-conduit Creation as a Merit of its Critical Frequency," *UPhN*, 1991, no 3, p143, in Russian.
25. A.D. Sakharov "Vacuum Quantum Fluctuations in Distorted Space and Theory of Gravitation," *DAN*, 1967, no 1, p 70, in Russian (see also: V.A. Beylin, G.M. Vershkov, Y.S. Grishkan, N.M. Ivanov, B.A. Nesterenko, A.N. Poltavtcev, "About Quantum Gravitation Effects in Isotropical Universe," *ZETPh*, 1980, no 6, p 2082, in Russian).
26. L.D. Landaw, E.M. Liftshitz, Theoretical Physics, vol IV, Science, GR PhML, Moscow, 1968, part 1, p 480, in Russian.
27. Shpolkiy E.V., Nuclear Physics, Moscow, GITGL, 1949, vol 1, p 523; 1950, vol 2, p 718, in Russian.
28. A.D. Dolgov, Y.B. Zeldovitch, M.V. Sahgin, Cosmology of Early Universe, MGU, Moscow, 1988, p 200, in Russian.
29. V.A. Bunin, "Newest issues of gravitation in the light of Classic Physics," Proc. 4th Astro-Geological Meeting Geographical Society of AS USSR, L., 1962, p 88, in Russian (see also: V.A. Bunin, "Unitary Electra-Gravitation Equations of Mathematical Physics," Auto-repherates of speeches of the section MOIP, 1965, no 1, p 4, in Russian.)
30. V.A. Dubrovskiy, "Elastic Model of Physical Vacuum," *DAS USSR*, vol 282, no 1, 1985, p 83, in Russian.
31. Adier S. Einstein, "Gravity as Symmetry-Breaking Effect in Quantum Field Theory," Rev. Mod. Phys., 1982, vol 54, no 3, p 729.
32. A.D. Sakharov, *TMPh*, 1975, vol 9, no 22, p 157.
33. G.T. Butorin, "To the Question about Quantum-Mechanical Nature of Gravitation," VINITI, Moscow, 1987, dep. N 5135-B87, p 49.
34. G.T. Butorin, "About possible origination of magnetism of rotating masses," VINITI, Moscow, 1989, dep. M 2139-B39., p 49, in Russian.
35. B.P. Bershadskiy, A.A. Mekhedkin, "Structured discretization of the basic types of composite relations of types of the matter," VINITI, Moscow, 1990, dep. N 40-B90, p 11, in Russian.
36. A.E. Akimov, B.P. Bershadskiy, A.A. Mekhedkin, "Frequency spectrum of physical fields in general interpretation," VINITI, Moscow, 1990, dep. K2826-B90, p 6, in Russian.
37. A.P. Ephremov, "Space-time spinning and torsion field effects," *Analytical Review*, MNTC VENT, Moscow, p 76, in Russian. (The same as #11. OF)
38. M.A. Markov, "Very Early Universe," Proc. of the Nuffield Workshop, Eds. G.W. Gibbson, S.W. Hawking, S.T. Sikiov, Cambridge, 1988, p 353.
39. J. Wiler, Prediction of Einstein, Mir, Moscow, 1970, p 112, in Russian.
40. I.D. Novikov, V.P. Frolov, Physics of Black Holes. Science, M., 1986, p 327, in Russian.
41. V.P. Mayboroda, A.E. Akimov, G.A. Maximova, V.Y. Tarasenko, V.K. Shkholniy, "Influence of the Torsion Fields to the Tint Melt," MNTP. VENT, pre-print N 49, M., 1994, 13 p, in Russian.
42. V.P. Mayboroda, A.E. Akimov, G.A. Maximova, V.Y. Tarasenko, V.K. Shkholniy, N.G. Palaguta, G.M. Moltchanovskaya, "Structure and properties of copper inherited from a melt after applying to it a torsion emission," MNTP VENT, pre-print N 50, Moscow, 1994, 11 p, in Russian.
43. A.E. Akimov, "Torsion Communications of the Third Millennium," Papers of International Conference "Modern Tele-Communication Technologies," Moscow, May 1995, in Russian.
44. A.E. Akimov, F.A. Ohatrin, A.F. Ohartin, V.P. Finogeev, M.H. Lomonosov, A.V. Loginov, "Detection and Processing of Torsion Information from Carriers of Cosmical Images," All-Russian Conf. "Perspective Information Technologies," Ul'anovsk, August 1995, in Russian.
45. N.A. Kozir'ev, V.V. Nasosov, "About Some Properties of Time Discovered by Astronomical Observations, *Issues of Universe investigation*, 1980, no 9, p 76, in Russian.
46. M.M. Lavrent'ev, I.A. Eganova, M.K. Lutzet, S.F. Phominikh, "About Distance Influence of Stars to Resistor," *Reports of AS USSR*, 1990, vol 314, no 2, p 352, in Russian.

47. A.E. Akimov, G.U. Kovaltchuk, V.G. Medved'ev, V.K. Oleynik, A.F. Pugatch, "Preliminary Results of the Astronomical Observations of Sky by Method of N.A. Kozir'ev," GAO AS Ukraine, Kiev, 1992, pre-print N GAO-92-5P, p 16, in Russian.
48. Toltchin V.I., "Inertsoid, forces of inertia as a source of movement," Perm, 1977, in Russian.
49. A.D. Dolgov, Y.B. Zeldovitch, M.V. Sahgin, "Cosmology of the Early Universe," Moscow, MGU Pub., 1988, p 199, in Russian.
50. The Manual of Free Energy Devices and Systems, complied by D.A. Kelly. D.A.K. WLPUB, Burbank California, 1986, Publ. N 1269/F-289.
51. Convegno Internazionale: Quale Fisica per 2000?, Bologna, 1991.
52. A.A. Grib, S.G. Mamayev, V.M. Mostepanenko, "Vacuum Quantum Effects in Strong Fields," Energo-atomizdat, Moscow, 1988, p 288, in Russian.
53. L.I. Matveyenko, "Visible Superlight Speeds of Components Scattering of Extra-Galactic Objects," *UPhN*, 1989, vol 140, no 3, p 469, in Russian.

CLOSED ELECTRIC CURRENT IN POLARIZED NON-HOMOGENEOUS MEDIA

George S. Turchaninov [1] and I.G. Turchaninov [2]

ABSTRACT

It is found with the help of the Maxwell theory that thermoelectric effects can exceed and be maintained in the non-homogeneous electrically-conducting media by an electrostatic field, not only by a temperature field. The hydrodynamic conditions of the closed steady-state electric current in non-superconductive media without energy dissipation, are deduced. It is shown that in the frame of the current paradigm, the results contradict the Second Law and therefore an extension of the Second Law of thermodynamics is proposed.

INTRODUCTION

Thermoelectric phenomena have been investigated in detail with application of the Onsager reciprocal relations in approach of the linear irreversible thermodynamics [1]. It is known that thermoelectric phenomena are excited when the outer temperature field is superimposed onto the nonhomogeneous medium in which initially an intrinsic field of a density gradient of the mobile electric charge carriers takes place. It is significant that the temperature field must be maintained continually, therefore thermoelectric effects are permanently accompanied by energy dissipation. Therefore, and in accordance with the Second Law, the total entropy of both the system in which the thermoelectric current flows, and the nearest surroundings, increase in time.

In this paper we will show that the closed electric current can also be excited and maintained by the outer electrostatic field in the nonhomogeneous media which was initially at thermal equilibrium. In this case, in contrast to the classic one, maintenance of the steady-state current doesn't yield energy consumption and isn't accompanied by increasing entropy of the system and its surroundings. On the basis of the results, the extended interpretation of the Second Law covering the case of the closed steady-state current in crossed potential fields is proposed

STEADY-STATE CLOSED ELECTRIC CURRENT IN A POLARIZED SYSTEM

A density of the electric current in some closed thermodynamic systems possessing the electronic conductivity can be written as [2]:

$$J = \rho \mu \nabla \varphi + \nabla (D\rho) , \qquad (2.1)$$

where ρ is the density of free electric charge carriers, μ is their mobility, D is their diffusion coefficient, φ is the local electric potential of medium. We rewrite Eq. (2.1) eliminating D with the help of the well-known Einstein relation

$$D = k\, T \mu / e,$$

[1] Radio Department, Krasnoyarsk State Technical University 660074 Krasnoyarsk Russia
E-mail address: tur@red.kgtu.runnet.ru

[2] Physics Department, Omsk State University 644077, Omsk, Russia

where k is Boltzmann's constant, e is the charge of a free electron, and T is the temperature. Such substitution is valid as the Einstein relation takes place both in the hydrodynamic and quasihydrodynamic approximations [2]. So we find:

$$\boldsymbol{J} = -\rho\,\mu\nabla\,\varphi + \frac{k}{e}\nabla\,(\rho\,\mu\,T)\,. \tag{2.2}$$

For a thermal equilibrium state of the reference system one can extract T out of the operator "nabla" in Eq. (2.2)and rewrite it as:

$$\boldsymbol{J} = \rho\,\mu\nabla\,\Big(\frac{kT}{e}\,\boldsymbol{ln}\,\rho\,\mu - \varphi\Big)\,. \tag{2.3}$$

In Eq. (2.3) we retained the mobility μ deliberately as a function of the operator "nabla" in spite of the fact that "nabla" doesn't effect the mobility of carriers in linear statistical models of electrically conducting media. One can see from Eq. (2.3) that the electric current in the thermalized system depends only on the generalized potential field. In section 4 we'll show that in this case the closed electric current should be absent. When in the reference system being initially at thermal equilibrium, the polarization process is arising under action of the applied electric field $-\nabla\varphi$, there the temperature field must also appear at least shortly. Consequently, the main question is if the temperature field will be retained after the end of the polarization process. It depends on the answer to this question if one could reduce Eq. (2.2) to Eq. (2.3) when analyzing the steady state of the reference system in the outer electrostatic field. We'll search this problem with the help of well-known equations of the theory of electricity

We consider the closed reference system H at equilibrium. Let the system H possesses a set of the following properties:

The properties following from the definition
- (α) The electric current $\boldsymbol{J}$ is absent;
- ($\alpha\alpha$) $\nabla T = 0$;
- ($\alpha\alpha\alpha$) H is not subjected to an action of the outer electrostatic field.

The properties relating to the electric property of H.
- (β) H possesses the electric conductivity. Let's assume the free electrons with the volume density ρ in the role of unique electric charge carriers;
- ($\beta\beta$) The whole system H is claimed to be eletroneutral, as commonly. It means that H contains immovable positive electric charges with the density ρ_+, so that full numbers of positive and negative charges in H are equal;
- ($\beta\beta\beta$) Let $\rho_+ = \rho_+(\boldsymbol{r})$, where $\boldsymbol{r}$ is the cartesian coordinates of a position inside H.

From ($\alpha\alpha\alpha$), ($\beta\beta$) and ($\beta\beta\beta$) one can elementarily deduce secondary properties of H as follows:
- (γ) $\nabla\rho \neq \nabla\rho_+$;
- ($\gamma\gamma$) There is the intrinsic field $-\nabla\varphi_i$ of the electric potential φ_i in H connected with inhomogeneous distribution of ρ_+;
- ($\gamma\gamma\gamma$) $\rho = \rho(\varphi_i)$;
- ($\gamma\gamma\gamma\gamma$) Vector fields $-\nabla\rho$, $-\nabla\rho_+$, and $-\nabla\varphi_i$ are collinear.

Apply to H the outer electrostatic field $-\nabla\,\varphi_e$ caused by the potential φ_e. The system H will be polarized under action of the applied field. We'll name the reference system in the new state as H'. Now we reconstruct the modified properties which H' doesn't inherit from H:

(ααα)' $-\nabla\varphi_e \neq 0$;

(γγ)' The macroscopic field $-\nabla\varphi$ acts in H', where $\varphi = \varphi_i + \varphi_e$;

(γγγ)' $\rho = \rho(\varphi)$.

Now we'll demonstrate that properties (α) and (αα) do not keep in H'. We'll prove it *ex adverso.* Let's assume that property (α) and, consequently, property (αα) have been passed from H into H'. Then we represent the local properties (β) and(βββ) by a system of differential equations. One of them can be derived from (α), (αα) and (2.2):

$$-\rho\mu\nabla\varphi + \frac{kT}{e}\nabla(\rho\mu) = 0. \qquad (2.4)$$

As the second equation we use one of Maxwell's equations written in the following form:

$$\nabla(\varepsilon\nabla\varphi) = \rho - \rho_+, \qquad (2.5)$$

where ε is the dielectric permittivity of H'. Instead of searching a solution of the system of the differential equations (2.4) and (2.5) we'll exhibit its geometric interpretations

DEDUCTION

Transform Eq. (2.5) into a more useful form. Therefore, first of all, we seek additional relations between ε and other variables in Eq. (2.5). Formal distribution of ρ and ρ_+ is written in the right-hand side of Eq. (2.5) in the explicit form. Hence ε can depend only on $\nabla\varphi$. On physical grounds, if the system H' is nonlinear with respect to the field $-\nabla\varphi$, then ε also depends on $\nabla\varphi$. So the left hand side of Eq. (2.5) is some function of $\nabla\varphi$:

$$\nabla(\varepsilon\nabla\varphi) = F(\nabla\varphi), \qquad (2.6)$$

where F is a surjective function. We'll examine replacement of the function (2.6) by the form

$$\nabla(\varepsilon\nabla\varphi) = F_1(\varphi + const). \qquad (2.7)$$

Adding in (2.7) *const* to φ we take into account the gauge invariance principle [3]. We have also: $\nabla\varphi = F_2(r)$, where F_2 is a surjective function. Combining both the last equation and Eq. (2.6), we can represent the left-hand side of Eq. (2.5) as the following functional:

$$\nabla(\varepsilon\nabla\varphi) = F_3(\boldsymbol{r}). \qquad (2.8)$$

where $F_3 = F \circ F_2$. It is obvious that F_3 is also a surjection. The potential (φ + const) can also be represented as a functional: $\varphi + const = F_4(\boldsymbol{r})$, where F_4 is a surjective function. Eq. (2.8) is transformed into Eq. (2.7) when F_4 is bijective. But then F_4^{-1} is also one-to-one correspondence [4]. We infer from this that $F_1 = F_3 \circ F_4^{-1}$ is a surjection. In terms of thermodynamics it means that any set of variables taken from the row $\nabla\varphi$, φ, $\boldsymbol{r}$ has a sense of the necessary and sufficient set of independent variables, in which space the expression in the left-hand side of Eq. (2.5) is a state function.

For the deduction to be continued, let us select continuous domains in system H', called as h_i, ($i = 1, \ldots n$), such that in each of them F_4 is a bijection. As one can find, this condition is fulfilled at the segments of force lines of the field $-\nabla\varphi$, which are limited either by the surface of H' or the nearest point where $\nabla\varphi = 0$. But one can seek a solution of the set of Eqs. (2.4) and (2.5) at any force line of $-\nabla\varphi$ independently from its vicinities. Therefore, we join a bundle of lines of $-\nabla\varphi$ into a single domain h_i. Finally, every selected domain h_i is bounded by a surface coinciding partly with both the surface of H' and surfaces of adjacent domains of a constant potential φ possessing dimensionality from 0 to 3. Among domains h_i there can be multiply-connected ones, but it does not influence the following conclusions.

Our following arguments will be relative to one arbitrary domain h_i. Bearing in mind above written we differentiate Eq.(2.5), express the left-hand side of the received equation in terms of the differential of φ and then group all equation terms together in its left-hand side. Ultimately we deduce the exact differential equation

$$\frac{d}{d\varphi}(\nabla(\varepsilon\nabla\varphi))\,d\varphi - d\rho + d\rho_+ = 0 \qquad (2.9)$$

At the same time φ, ρ and ρ_+ are state functions in the space coordinate system. Therefore, we can embody the operator d as $dr \cdot V$ and after dividing Eq. (2.9) by dr rewrite (2.9):

$$\frac{d}{d\varphi}(\nabla(\varepsilon\nabla\varphi))\nabla\varphi - \nabla\rho + \nabla\rho_+ = 0 \qquad (2.10)$$

We also rewrite Eq. (2.4) in the following form:

$$\nabla\varphi - \frac{kT}{e\rho}\nabla\rho - \frac{kT}{e\mu}\nabla\mu = 0. \qquad (2.11)$$

Multiplying (2.11) by dr we receive the second exact differential equation

$$d\varphi - \frac{kT}{e\rho}d\rho - \frac{kT}{e\mu}d\mu = 0. \qquad (2.12)$$

From Eqs. (2.9) and (2.12) one can express φ over the last two variables: $\varphi = \varphi(\rho, \mu) = \varphi(\rho, \rho_+)$. It is evident from the last that in general case $\mu = \mu(\varphi, \rho, \rho_+)$, otherwise:

$$\nabla\mu = \frac{\partial\mu}{\partial\varphi}\nabla\varphi + \frac{\partial\mu}{\partial\rho}\nabla\rho + \frac{\partial\mu}{\partial\rho_-}\nabla\rho_+ . \qquad (2.13)$$

Both the last equation and some following ones which include a mobility coefficient μ, have an abnormal appearance. Hence, we could complete our proof *ex adverso* immediately and successfully. However, we don't like to loose generality of our proof when examining concrete models of electrically-conducting media, so we conduct our deduction to the end formally. Thus inserting (2.11) into (2.13) and transforming the received equation we obtain:

$$\left(\frac{e\mu}{kT} - \frac{\partial\mu}{\partial\varphi}\right)\nabla\varphi = \left(\frac{\mu}{\rho} + \frac{\partial\mu}{\partial\rho}\right)\nabla\rho + \frac{\partial\mu}{\partial\rho_-}\nabla\rho_+ . \qquad (2.14)$$

Geometrical interpretation of Eqs. (2.10) and (2.14) follow. They describe triangles in the Euclidian space, which sides are parallel to tangents of the vectors $\nabla\varphi$, $\nabla\rho$ and $\nabla\rho_+$ in the chosen point of the system H'. From (2.10) and (2.14) it follows that these tangents lie in the same plane. In turn, the triangles are similar to one another because of equality of the corresponding angles. The similarity coefficient can be estimated for example, as

$$\frac{(\mu/\rho + \partial\mu/\partial\rho)\nabla\rho + (\partial\mu/\partial\rho_+)\nabla\rho_+}{\nabla\rho - \nabla\rho_+} .$$

From this the condition of similarity of triangles follows:

$$\frac{\partial\mu}{\partial\rho} + \frac{\partial\mu}{\partial\rho_+} = -\frac{\mu}{\rho} .$$

After integrating, this yields

$$\mu = C / \rho , \qquad (2.15)$$

where C is a parameter. Eq. (2.15) gives us the condition of integrability of the system of Eqs. (2.4) and (2.5). But substitution of μ from (2.15) into (2.4) results in $\nabla\varphi = 0$, that is contrary to the starting conditions of our reasoning. That presented above can be extended over all the domains h_i. Therefore, in general case the set of Eqs. (2.4) and (2.5) is not integrable. Another result can be received if the fields $-\nabla\rho$, $-\nabla\rho_+$ and $-\nabla\varphi$ are collinear. In this case, Eqs. (2.10) and (2.14) are not relative to similarity of triangles, therefore Eqs. (2.4) and (2.5) do not contradict to one another. One can easily find from above, that the system H' inherits the properties (α), (αα) and (γγγγ) in the following cases:

(i) $\nabla\rho_+ = 0$. The appropriate reference system H is a homogeneous one;

(ii) The fields $-\nabla\varphi_e$ and $-\nabla\rho_+$ are collinear to one another (so-called one dimensional case).

In other cases besides (i) and (ii), there are established the following properties in H':

(α)' $J \neq 0$, J is closed;

(αα)' $\nabla T \neq 0$;

(γγγγ)' The fields $-\nabla\rho$, $-\nabla\rho_+$ and $-\nabla\varphi$ are mutually non-collinear.

We'll denote the system H' possessing the properties (α)', (αα)' and (γγγγ), as H". For the system H" to be realized it is sufficient to find two nonadjacent dots at the bounding surface of H" belonging to the same domain of $\rho_+ = const$, and apply to them the outer potential φ_e of different values. The simplest example of this type system H" is shown in Fig. 1.

In the following sections we'll base our reasonings on the above received results with the help of the Maxwell theory.

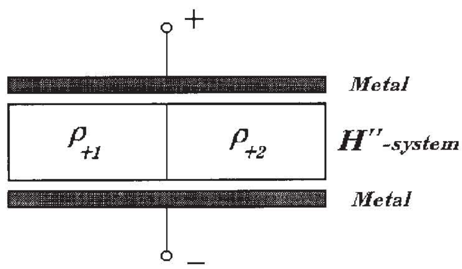


Fig 1. The example of the system H" consisting of two subsystems both of different values ρ_+. Signs "plus" and "minus" clarify a method of electric potential application.

3. BALANCE EQUATIONS OF THE CLOSED ELECTRIC CURRENT

We consider the system H". Eq. (2.2) cannot be reduced to Eq. (2.3) when the system has the property *(αα)'*. It is obvious that the total energy dissipation of the closed current ***J*** is equal to zero while H" stays in the steady state. Let us look for mechanisms of spontaneous realization of this constraint. Bearing in mind that we write the balance equations for various terms of energy of the current ***J*** in the local form [5]:

$$\rho \frac{\partial \varphi}{\partial t} + \nabla \cdot \boldsymbol{J}\varphi = \sigma_\varphi , \tag{3.1}$$

$$\rho \frac{\partial g}{\partial t} + \nabla \cdot (\hat{P}\boldsymbol{v} + \boldsymbol{J}g) = - \sigma_\varphi + \sigma_v , \tag{3.2}$$

$$\rho \frac{\partial u}{\partial t} + \nabla \cdot (\boldsymbol{J}u + \boldsymbol{J}_q) = - \sigma_v , \tag{3.3}$$

$$\rho \frac{\partial w}{\partial t} + \nabla \cdot (\hat{P}\boldsymbol{v} + \boldsymbol{J}w + \boldsymbol{J}_q) = 0 , \tag{3.4}$$

In Eqs. (3.1) - (3.4) $\boldsymbol{J}$ and $\boldsymbol{J}_q$ are local densities of the electric current and the heat flow; *g, u* and *w* are the densities per unit of electric charge of the kinetic, internal and total energy of $\boldsymbol{J}$ respectively, *t* is the time,

$$\hat{P} = p\, \hat{\delta} + p^v \hat{\delta} + \hat{P}^{vs} \tag{3.5}$$

is the total pressure tensor of the electron gas, $p = p\,(\rho, T)$ is the scalar hydrostatic pressure, $\hat{\delta}$ is the unit tensor,

$$p^v = \xi\, \nabla \cdot \mathbf{v} \tag{3.6}$$

is the trace of the viscous pressure tensor describing the isotropic part of $\hat{P}$, ξ is the second viscosity coefficient of $\boldsymbol{J}$, $\boldsymbol{v}$ is the velocity of $\boldsymbol{J}$,

$$\hat{P}^{vs} = 2\,\eta\, (\mathring{\nabla}\, \boldsymbol{v})^s \tag{3.7}$$

is the symmetric part of the viscous pressure tensor with its trace equal to zero, η is the first viscosity coefficient of $\boldsymbol{J}$, $(\mathring{\nabla}\, \boldsymbol{v})^s$ is the symmetric part of the velocity gradient tensor with its trace equal to zero,

$$\sigma_\varphi = \boldsymbol{J} \cdot \nabla \varphi , \tag{3.8}$$

$$\sigma_v = \hat{P} : \nabla \boldsymbol{v} . \tag{3.9}$$

The symmetric viscous pressure tensor of the Newtonian flow is used as $\hat{P}$. Practically this constraint does not restrict the generality of our reasonings [6]. The mass density ρ in Eqs. (3.1)-(3.4) is time-independent because of $\boldsymbol{J}$ being steady state. Taking into account (3.8) and continuity of $\boldsymbol{J}$, Eq. (3.1) can be reduced to $\partial \varphi / \partial t = 0$. However we'll not do this, because the terms of Eq. (3.1), which we may to reduce have a different physical meaning. Nevertheless, it follows from the last equality that the potential energy of $\boldsymbol{J}$ is a locally preserved quantity.

One can conclude from (3.2) and (3.3) that in general case *g* and *u* are reserved in time quantities. We'll say that in these equations σ_φ represents the φg-coupling between the potential and kinetic energy, and σ_v represents the *gu*-coupling between the kinetic and internal energy of $\boldsymbol{J}$.

Now we extract the dosed current tube with an elementary cross-section δs and with a surface formed by streamlines of $\boldsymbol{J}$ in H". Let us restrict the upper limit of δs so that the current density $\boldsymbol{J}$ will be constant along any cross-section elementary area. Then as it follows from the current tube definition, the product $\delta s\, \boldsymbol{J}$ forms a vector which modulus is constant, and a bulk integral of δs over the extracted tube is zero, i.e.

$$\oint \delta_\varphi \, dl \, \delta s = \delta s \, J \oint \nabla\varphi \, dl = 0$$

where dl is a differential of some streamline inside the tube. Physical interpretation of this result is as follows. Total energy interaction between the closed current tube and the electrostatic field is equal to zero. Closure of the current tube is maintained by two current components – drift and diffusion ones. The Joule heat is extracted at tube segments where the drift current dominates. A heat of surroundings is absorbed at other segments where the diffusion current prevails. The above results can be applied to any current tube chosen arbitrarily. Hence, we conclude that the total energy interaction between the closed current ***J*** flowing in H" and the outer electrostatic field is zero.

Eq. (3.4) seems like a conservation law. However, in general case, a composition of the full energy of ***J*** is nonconserved locally owing to φg- and gu-coupling action.

Now we'll derive from the Gibbs equation the entropy balance equation of ***J*** in the local form. Let's assume that all components of H" are immovable with the exception of the current ***J***. From this it follows, in particular, that ***J*** does not produce the mechanical work. Write the fundamental Gibbs equation for ***J*** in the integral form:

$$S = S\,(U,\ V,\ N,\ Q)\ , \tag{3.10}$$

where S is the entropy, U is the internal energy, V is the volume occupied by ***J***, N and Q are the mole quantity and the total electric charge of the Fermi gas constituting ***J***. Now we make use of S being a first-order homogeneous function [7], and decrease by one the number of variables in the right-side part of Eq. (3.10). So Eq. (3.10) related to unit of volume, can be presented in the following form:

$$\rho s = \rho s\,(\rho u,\ \rho n,\ \rho)\ . \tag{3.11}$$

where s and n are the densities of S and N, respectively, per unit of electric charge. Further, we can decrease the number of variables in Eq. (3.11) once more in the following way. Multiplying n by Faraday's constant, we obtain the unit and hence eliminate n from Eq. (3.11). This conversion of n requires only the dimensionality of the conjugated with n extensive variable, i.e., the Fermi gas chemical potential, to be changed simultaneously. With the above stated, we receive in the ordinary way from (3.11), the differential equation of the entropy in the form per unit of volume:

$$d\,\rho\,s = \frac{1}{T}\,d\rho u - \frac{\theta + \varphi}{T}\,d\,\rho\ , \tag{3.12}$$

where θ is the electronic Fermi level that is measured in units of a potential. Dividing both parts of Eq. (3.12) by dt one can receive the entropy balance equation of ***J*** in the substantive form:

$$\frac{d\,\rho\,s}{d\,t} = \frac{1}{T}\,\frac{d\,\rho\,u}{d\,t} - \frac{\theta + \varphi}{T}\,\frac{d\,\rho}{d\,t}\ . \tag{3.13}$$

From the continuity equation of ρ and continuity of ***J*** it follows that $d\,\rho\,/d\,t = 0$. Hence, we omit the second term in the right-hand side of Eq. (3.13). Now from Eqs. (3.13) and (3.3) we find the entropy balance equation of ***J*** in the local form:

$$\rho\,\frac{\partial s}{\partial t} + \nabla\cdot\left(\frac{\boldsymbol{J}_q}{T} + \boldsymbol{J}\,s\right) = \boldsymbol{J}_q\cdot\nabla\,\frac{1}{T} - \frac{\sigma_v}{T}\ . \tag{3.14}$$

Let us express σ_v from Eqs. (3.5)-(3.7), (3.9) and then substitute it into Eq. (3.14). The result is given by

$$\rho \frac{\partial s}{\partial t} + \nabla \cdot \left(\frac{\boldsymbol{J_q}}{\boldsymbol{T}} + \boldsymbol{J} s \right) = \sigma_s \tag{3.15}$$

where the entropy production per unit of volume is

$$\sigma_s = -\frac{1}{T}(p + \xi \nabla \cdot \boldsymbol{v}) \nabla \cdot \boldsymbol{v} - \frac{2\eta}{T} (\overset{\circ}{\nabla} \boldsymbol{v})^s : (\overset{\circ}{\nabla} \boldsymbol{v})^s + \boldsymbol{J_q} \cdot \nabla \frac{1}{T} . \tag{3.16}$$

Now we write a set of the necessary conditions for $\boldsymbol{J}$ to be steady-state, as the following set of equations:

$$\frac{\partial \rho}{\partial t} = 0, \quad \frac{\partial \varphi}{\partial t} = 0, \quad \frac{\partial g}{\partial t} = 0, \quad \frac{\partial u}{\partial t} = 0, \quad \frac{\partial s}{\partial t} = 0 \qquad \text{(3.17) - 3.21)}$$

We know already from above that the first two equalities have been fulfilled. One can infer from Eqs. (3.2), (3.3) and (3.8) the following conditions for Eqs. (3.19) and (3.20) to be in force:

$$\nabla \cdot (\hat{P} \boldsymbol{v} + \boldsymbol{J} \varphi + \boldsymbol{J} g) = \sigma_v \tag{3.22}$$

$$\nabla \cdot (\boldsymbol{J} u + \boldsymbol{J_q}) = -\sigma_v \tag{3.23}$$

It can be revealed from Eq. (3.15) that Eq. (3.21) is maintained by the conditions

$$\nabla \cdot \left(\frac{\boldsymbol{J_q}}{\boldsymbol{T}} + \boldsymbol{J} s \right) = 0 \tag{3.24}$$

$$\sigma_s = 0 \tag{3.25}$$

The last equation is written in accordance with the Second Law. Consider in detail Eq. (3.16). The second term of the right-hand side of Eq. (3.16) represents the only bilinear form of two second rank tensors. The Curie principle yielding the quantity of this term must be non-negative irrespective of other equation terms [8]. Consequently, for the condition expressed by Eq. (3.25) to be valid, this term must be identically zero. It is possible if the velocity vector submits to the following condition:

$$(\overset{\circ}{\nabla} \boldsymbol{v})^s : (\overset{\circ}{\nabla} \boldsymbol{v})^s = 0$$

or, what is the same,

$$\frac{\partial v_\alpha}{\partial x_\beta} = -\frac{\partial v_\beta}{\partial x_\alpha}; \quad \frac{\partial v_\alpha}{\partial x_\alpha} = \frac{\partial v_\beta}{\partial x_\beta}; \quad (\alpha, \beta = x, y, z) \tag{3.26}$$

These conditions as realized, eliminate energy dissipation depending on the shear viscosity of $\boldsymbol{J}$. The second equality (3.26) is striking. If there were requirement all diagonal elements of the matrix $\nabla \boldsymbol{v}$ to be zeros, our deduction would be reduced to the case of the incompressible flow. By analogy with above, both the first and the third terms of the right-hand side of Eq. (3.16) should be non-negative quantities independent of one another.

As to the first term, this constraint means $\nabla \cdot \boldsymbol{v} = 0$, i.e., ***J*** must be incompressible. Not being restricted to the case of incompressible flow, we come back to the second section. Eq. (2.2) implies that ***J*** is a product of joint effect of four potential fields: $-\nabla\varphi$, $-\nabla\rho$, $-\nabla\mu$, and $-\nabla T$. These give rise to the relevant thermodynamic forces. As one can find from Eq. (2.2), these forces can be reduced to two generalized potential forces because they are coupled all together by linear relations. On the other hand, only two thermodynamic forces are taken into account in classical thermoelectricity. For the case of the one-component flow these can be expressed, for example, as $-\nabla\varphi$ and $-\nabla \ln T$ [1]. So, one can see that the fields of gradients of density and mobility of charge carriers are not considered. Including into consideration these potential fields, we will show how the first and the third terms of the right-hand side of Eq. (3.16) can be brought together as bilinear forms of the same tensor rank.

Formally, the first term of the right-hand side of Eq. (3.16) can be rewritten as the symmetric bilinear form of first rank tensors [4]

$$\frac{1}{T}\left(-p\mu\nabla\varphi + p\boldsymbol{v}_{dif} - \xi\ \boldsymbol{v}\boldsymbol{v}\ \frac{\nabla\rho}{\rho}\right)\frac{\nabla\rho}{\rho}, \tag{3.27}$$

where $\boldsymbol{v} = \boldsymbol{v}_{dr} + \boldsymbol{v}_{dif}$, $\boldsymbol{v}_{dr} = -\mu\nabla\varphi$ is the drift current velocity, and $\mathbf{v}_{dif}$ is the diffusion current velocity. Next we represent the term of σ_s caused by the thermodynamic force $-\nabla\varphi$ as $-\boldsymbol{J}\nabla\varphi/T$. From Eq. (2.2) we find this term in the expanded form:

$$-\frac{\boldsymbol{J}\cdot\nabla\varphi}{T} = \frac{k\rho\mu}{e}\left(\frac{e}{kT}\nabla\varphi - \nabla\ln T - \nabla\ln\rho - \nabla\ln\mu\right)\nabla\varphi \tag{3.28}$$

We select from the right-hand side of Eq. (3.28) and from the expression (3.27) terms describing cross-interaction between thermodynamic forces $-\nabla\varphi$ and $-\nabla \ln\rho$. These are $-\frac{k\mu\rho}{e}\nabla\varphi\nabla\ln\rho$ and $-\frac{p\mu}{T}\nabla\varphi\nabla\ln\rho$. Using the Onsager reciprocal relations, we equate the quantities $k\mu\rho/e$ and $p\mu/T$ in the last two expressions to one another. As a result, it gives the following expression for the Fermi-gas hydrostatic pressure:

$$p = \frac{\rho}{e}kT \tag{3.29}$$

Eq. (3.29) coincides with the approximated equation of the ideal Fermi-gas state derived for elevated temperatures and small electron density [9].

Thus, we have shown that both the first and the third terms of the right-hand side of Eq. (3.16) can be presented as symmetric bilinear forms of first rank tensors. Hence, as the Curie principle yields, sum of these terms must be a non-negative quantity. It follows from above and from Eqs. (3.5) - (3.7), (3.9), (3.16), (3.25) and (3.26) that

$$\boldsymbol{J}_q\cdot\nabla\frac{1}{T} = \frac{1}{T}\sigma_v \tag{3.30}$$

where

$$\sigma_v = (\rho + \xi\nabla - \boldsymbol{v}) \tag{3.31}$$

Eq. (3.30) expresses the condition of full reversibility (in space) of dissipation of the kinetic energy of ***J*** and, more widely, any Newtonian flow's velocity which obeys the conditions (3.26). As it can be noticed from Eq. (3.30), the temperature field arises in H" necessarily when the steady-state current ***J*** flows. So, the property *(αα)'* of the system H", which was derived in section 2, is approved. In the next section, we will demonstrate that total dissipation reversibility in space can take place only when a steady-state flow is closed.

Now we return to Eq. (3.10) and bearing in mind that *S* should be a first-order homogeneous function, write the Gibbs equation in the integral form per unit of electric charge:

$$s = s\,(u,\ v,\ \frac{N}{Q})\ , \tag{3.32}$$

where *v* is the volume per unit of electric charge. The other quantities were defined above. Taking into account that for one-component flow, the quantity *N/Q* is constant, we express from Eq. (3.32) the Gibbs equation in the entropy form, per unit of electric charge:

$$\mathrm{ds} = \frac{1}{T}du + \frac{p}{T}dv\ . \tag{3.33}$$

The second term of the right-hand side of Eq. (3.33) is zero because the current ***J*** does not perform mechanical work in the model taken into consideration. Based on this, we convert the operator *d* into $d\,\boldsymbol{r}\cdot\nabla$, reduce both parts of Eq. (3.33) by $d\,\boldsymbol{r}$ and finally result from (3.33)

$$\nabla s = \nabla u/T\ . \tag{3.34}$$

Now, combing Eqs. (3.23), (3.30), and (3.34), one can easily deduce Eq. (3.24). Finally, we summarize the set of Eqs. (3.22), (3.23), (3.26) and (3.30), containing all necessary and sufficient conditions for closed current in the given model to be steady-state.

In this section we have shown that the steady-state closed electric current ***J*** can exist in H" satisfying the balance equations for energy and entropy. With that, the kinetic energy of ***J*** is reserved in whole but not locally, and the velocity gradient of ***J*** has such appearance that a local energy dissipation caused by the shear viscosity of flow is eliminated. The effect of the bulk viscosity falls off to zero integrally along every loop of electric current.

4. STREAMLINES PATTERN NEAR EQUILIBRIUM POINT

In this section, having applied the autonomic systems theory, we investigate the possibility of formation of the electric current closed streamlines in the system H" acting under the influence of the outer electrostatic field. First of all, let us prove the following lemma that will be useful later.

Lemma. Suppose, it is given the autonomic normal system of second-order equations:

$$\boldsymbol{v} = \boldsymbol{f}\,(\boldsymbol{r});\ \ \boldsymbol{v} = (v_x\,,\, v_y\,);\ \ \boldsymbol{r} = (x,y);$$

where *x, y* are the Cartesian coordinates of a point at some flat open set Δ, $\boldsymbol{v} = \frac{d\,\boldsymbol{r}}{d\,t}$, and *t* is an independent variable. Let the functions $f_i(x,y)$ and their first-order partial derivatives be defined and continuous at Δ. Let there also be another autonomic system made up:

$$\boldsymbol{J} = \rho\,\boldsymbol{v}\,;\qquad \rho = \rho\,(\boldsymbol{r}) \tag{4.1}$$

where ρ is a scalar quantity satisfying the condition

$$\nabla \cdot (\rho v) = 0 \tag{4.2}$$

Then, if Eqs. (3.26) are valid for ***v***, the integral of the system (4.1) is a set of smooth closed curves at Δ, which are mutually and self-disjoint and enclose the equilibrium point.

Proof. One can situate the coordinate axes so that Eqs. (3.26) yield the following Jacobian:

$$\frac{D(v_x, v_y)}{D(x, y)} = \begin{vmatrix} a & b \\ -b & 0 \end{vmatrix} > 0 \,, \tag{4.3}$$

where $a = a(r), b = b(r)$. Take some point at Δ and reduce ***v*** and ***J*** in the neighborhood of it to its linear forms. Then from (4.1), (4.2) and (4.3) we find:

$$\frac{D(v_x, v_y)}{D(x, y)} = \begin{vmatrix} 0 & b_0 \\ -b_0 & 0 \end{vmatrix} \,, \tag{4.4}$$

$$\rho = \rho_0 \,,$$

where b_0, ρ_0 are constants. It follows from Eq. (4.4) that the lines of the field v nearest to the given point are concentric circles, which enclose that point. Hence, the given point just becomes the equilibrium point. But the fields ***v*** and ***J*** differ from one another by the constant ρ_0 only. Therefore, the streamlines of ***J*** have the same shape.

Later on we'll use some propositions of the autonomic systems theory, which are [10]:

(*j*) Any two trajectories have no common points;

(*jj*) If any trajectory intersects itself, it means that it is either a closed trajectory or an equilibrium point;

(*jjj*) *Trajectories* fill the whole phase space (the phase plane Δ in our case).

We assume that moving away from the equilibrium point along Δ we meet some closed streamline of J which may be named j_c. Allow that immediately behind there occurs a nonclosed streamline named j_i, which according to (4.2), must end at infinity. Two cases can be distinguished there. Let, in the first case, j_c be adjacent by its convexity side with the single streamline j_i. Then one can verify, with the help of a simple graphic construction, that if j_i has no inflection points it cannot satisfy simultaneously the conditions (j), (jj), and (jjj). Because j_i cannot have inflection points, it must be closed in opposite to assumption. In the second case, we assume a few nonclosed streamlines to be adjacent to the convexity side of j_c. Arguing as above, we imply that all those streamlines must loop around the equilibrium point. And taking into account the condition (j), we receive a similar result as in the first case. Finally, we conclude that every streamline of ***J*** is adjacent by its convexity side with a single closed streamline.

At last, we can state that power lines of v are mutually and self-disjointed because the functional $v = f(r)$ is claimed as an autonomic normal system. The lemma is proven.

We consider the system H" in which the steady-state current ***J*** is flowing and its velocity satisfies the conditions (3.26). Making use of the above lemma, one can conclude that all streamlines of ***J*** are closed around the equilibrium point. From this, it also follows that the local energy dissipation caused by the shear viscosity of the electron flow can be zero only in the case where streamlines are closed. Near the equilibrium point ***J*** is similar to an incompressible flow and its streamlines represent coaxial circles.

Now we analyze more explicitly the ***J*** pattern in the broad vicinities of the equilibrium point located at the origin of the cartesian reference system. We will use the simplified expressions of the electron flow velocity and density in the form of the following Taylor-series expansions in powers of *x, y* :

$$\rho = \rho_0 + \rho_1 x + \rho_2 y + \rho_3 x^2 + \rho_4 xy + \rho_5 y^2 ,$$

$$v_x = q_1 x + q_2 y + q_3 x^2 + q_4 xy + q_5 y^2 + q_6 x^3 + q_7 x^2 y + q_8 xy^2 + q_9 y^3 ,$$

$$v_y = r_1 x + r_2 y + r_3 x^2 + r_4 xy + r_5 y^2 + r_6 x^3 + r_7 x^2 y + r_8 xy^2 + r_9 y^3 ,$$

where ρ_i, q_j, r_j ($i = 0,...5$, $j = 1,... 9$) are constant coefficients. From these and from Eqs. (3.26), (4.1), (4.2), and using the lemma we find:

$$v_x = h\,(4\,\rho_0^2 y + \rho_0 \rho_2 x^2 - 2\,\rho_0 \rho_1 xy - \rho_0 \rho_2 y^2 + zx^3/3 - 3wx^2 y - zxy^2 + wy^3\,) , \tag{4.5}$$

$$v_y = h\,(-\,4\,\rho_0^2 x + \rho_0 \rho_1 x^2 + 2\,\rho_0 \rho_2 xy - \rho_0 \rho_1 y^2 + wx^3 + zx^2 y - 3wxy^2 - zy^3/3\,) , \tag{4.6}$$

$$J_x = h\rho_0\,(4\,\rho_0^2 y + \rho_0 \rho_2 x^2 + 2\,\rho_0 \rho_1 xy + 3\,\rho_0 \rho_2 y^2 + 2\,\rho_0 \rho_4 x^3/3 - tx^2 y + 2\,\rho_0 \rho_4 xy^2 - ry^3\,) , \tag{4.7}$$

$$J_y = h\rho_0\,(-\,4\,\rho_0^2 x - 3\,\rho_0 \rho_1 x^2 - 2\,\rho_0 \rho_2 xy - \rho_0 \rho_1 y^2 + sx^3 - 2\,\rho_0 \rho_4 x^2 y + txy^2 - 2\,\rho_0 \rho_4 y^3/3\,) , \tag{4.8}$$

where

$$r = \rho_1^2/2 + \rho_2^2/2 - 2\,\rho_0 \rho_3/3 - 10\,\rho_0 \rho_5/3 ,$$

$$s = \rho_1^2/2 + \rho_2^2/2 - 10\,\rho_0 \rho_3/3 - 2\,\rho_0 \rho_5/3 ,$$

$$t = \rho_1^2/2 + \rho_2^2/2 - 2\,\rho_0 \rho_3 - 2\,\rho_0 \rho_5 ,$$

$$w = \rho_1^2/2 + \rho_2^2/2 + 2\,\rho_0 \rho_3/3 - 2\,\rho_0 \rho_5/3 ,$$

$$z = 2\,\rho_0 \rho_4 - 3\,\rho_1 \rho_2 ,$$

h is an arbitrary real nonzero quantity. Above set of equations for ***v*** and ***J*** answers the following conditions:

$$\frac{\partial v_x}{\partial x} = \frac{\partial v_y}{\partial y} ; \quad \frac{\partial v_x}{\partial y} = \frac{\partial v_y}{\partial x} ; \quad \nabla \cdot \mathbf{J} = 0; \quad \mathbf{J} \times \mathbf{v} = 0 .$$

By solving the system (4.5), (4.6), and taking into account collinearity of ***v*** and ***J***, we find the set of streamlines of ***J***

$$24\,\rho_0^2 (x^2 + y^2) - 4\,\rho_0 (\rho_1 x^3 + \rho_2 y^3) - 3w\,(x^4 - y^4) = h_1 , \tag{4.9}$$

where $h_1 > 0$ is a parameter. Fig. 2 illustrates the pattern example of streamlines of ***J*** near the equilibrium point calculated with the help of Eq. (4.9). The quantities ρ_i are chosen so that $p > 0$ for all values *x, y* in Fig. 2. One can easily find from Eqs. (4.7) and (4.8) that closed streamlines of the electric current are converted from the third-order curves directly into concentric circles when approaching the equilibrium point.

In accordance with Eq. (3.30), the temperature field appears when withdrawing from the equilibrium point and therefore out of the linear model. Then the current is described by Eq. (2.2) but not by Eq. (2.3). Let us show that the current streamlines corresponding to Eq. (2.2) can also satisfy Eqs. (4.7) and (4.8). We rewrite Eq. (2.2) in the simplified form

$$\boldsymbol{J} = \alpha\, \nabla \varphi + \beta_0 \nabla\ \psi\ , \tag{4.10}$$

where one can find quantities of the kinetic coefficients $\alpha = \alpha(\boldsymbol{r})$, $\beta_0 = const$, and thermodynamic powers $-\nabla \varphi$, $-\nabla \psi$ comparing Eqs. (4.10) and (2.2). Our following reasoning is simple, therefore we restrict ourselves by its qualitative presentation. We represent α, φ and ψ in the form of the Taylor-series expansions in powers of *x, y* and remain there the terms including *x, y* in total powers from 0 to 3 for α and from 0 to 4 for φ and ψ. In addition, we assume existence of the appropriate derivatives of α, φ and ψ. Then we substitute obtained expressions into Eq. (4.10) and preserve in the right-hand side of this equation the terms containing variables *x* and *y* in total powers from 0 to 3. Further, we demand $\alpha_0 \neq 0$, $\beta_0 \neq 0$, since kinetic coefficients cannot change their sign in space to opposite because they are directly proportional to appropriate mobilities. And finally, we set the terms of the right-hand sides of equation derived from Eq. (4.10), and Eqs. (4.7), (4.8), corresponding to the same total powers of *x* and *y*, to be equal. As a result of above operations, we receive the system of 20 equations containing β_0 and *38* coefficients, entering into the expressions of α, φ and ψ in the capacity of variables. We have discovered that this system is a solvable one if a number of variables is reduced to twenty, treating the rest as parameters. For example, one can take in the coefficients φ_i, ψ_j (i = 1,...14, j = 1,...6) as variables. From above arguing it follows that the current ***J*** presented by Eq. (2.2) can be closed.

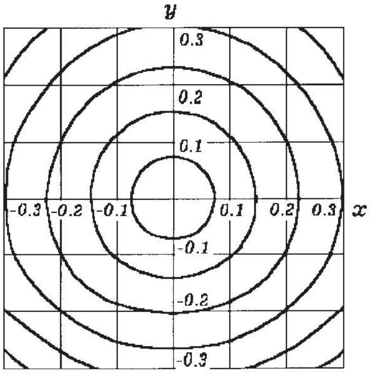


Fig. 2. The set of streamlines of ***J*** near the equilibrium point computed for $\rho_0 = \rho_3 = \rho_4 = \rho_5 = 1$, $\rho_1 = 0$, $\rho_2 = 3.2$.

In the similar way we explore the following special cases:

(*k*) In the formula (4.10) $\nabla\ \psi = 0$ (the case of a single thermodynamic power);

(*kk*) Both kinetic coefficients in (4.10) are constants α_0, β_0 (this case known as the case of a homogeneous medium).

(*kkk*) The fields $-\nabla \varphi$ *and* $-\nabla \psi$ are collinear

In all mentioned cases the above system of equations is unsolvable, and therefore the current ***J*** cannot be closed. One can note full analogy between the cases *(kk), (kkk)* and appropriate particular cases *(i), (ii)* considered in the second section.

We should like to select interpretation of the case (*k*). As it was shown in the second section, the electric current ***J*** is generated by the electric field. In turn, ***J*** induces the temperature gradient and the heat flow $\boldsymbol{J}_q$. Therefore, two thermodynamic forces in Eq. (2.2) must be simultaneously either present or absent. With the help of Eq. (2.3) one can imagine how both thermodynamic forces are vanishing when $\nabla \varphi \neq 0$. For this, the expression standing under the operator "nabla" in Eq. (2.3) must have a constant value over all the system. Then the electric current is absent. The case *(k)* yields just the same result. From *(k)* and Eq. (3.30), it follows also that the outer electrostatic field can not initiate and hold up the steady-state closed current in superconductive media since they are isothermal. Nevertheless, one can immediately obtain from Eq. (2.2) the following expression for the electric current curl:

$$\nabla \times \boldsymbol{J} = \nabla \varphi \times \nabla (\rho\mu) \; .$$

Therefore, appearance of the electric curls in crossed potential fields $-\nabla \varphi$ *and* $\nabla (\rho\mu)$ is a basic property of media possessing the electrical conductivity. One can assume that jump of the system H" into the superconductive state yields degeneracy of the closed macroscopic current to a set of non-dissipating electric curls.

5. SPECULATIONS AND CONCLUSIONS

One of many equivalent formulations of the Second Law of Thermodynamics claims that if a system participates in some thermodynamic process, the over-all entropy of the Universe can not be decreased in consequence of this process regardless of changing of the entropy of the system [11]. Let us show that behavior of the above examined system H" with the closed current ***J*** contradicts this formulation. As it was found in the third section, the total energy dissipation at H" equals zero, i.e.

$$\int_V \sigma_v \, dV = 0 \; . \qquad (5.1)$$

From (3.23) and (5.1) with the help of Gauss' divergence theorem one can easily deduce

$$\oint_\Omega \boldsymbol{J}_q \cdot d\,\Omega = 0 \; . \qquad (5.2)$$

In Eqs. (5.1) and (5.2) V is the volume of H" and Ω is the bounding surface area of H".

Eq. (5.2) includes cases of both the adiabatically insulated system H" and the non-adiabatic system in which the continuous heat flux $\boldsymbol{J}_q$ flows through. For the second case to be realized, the system bounding surface must be heat conducting. Fig. 3 illustrates the system H" in which the steady-state closed electric current ***J*** flows. An arbitrary line of the current ***J*** is depicted conditionally by the closed dotted line. The bold parts of the dotted line indicate segments where heat is either strongly evolved or absorbed by the electric current. The temperature of these segments is designated as T_h (evolution of heat) and T_l (absorption of heat), so that $T_h > T_l$. To the left and to the right of H", two external reservoirs are shown with their temperature T_1 and T_2. Let firstly $T_1 = T_2$. Heavy pointers indicate direction of the heat flow motion in the case of a non-adiabatic system and broken pointers indicate the resulting path of heat flowing between the reservoirs.

In Fig. 4 correlation of T_h, T_l, T_1 and T_2 is shown after ***J*** becomes steady. From Fig. 3 and Fig. 4 one can easily conclude that the non-adiabatic system with the closed electric current works as a heat pump. The particular property of this heat pump is that it works without consumption of energy from outside except for the period of the initial polarization of H". This result contradicts the above formulation of the Second Law. Bearing in mind that the foregoing deduction is generically exact in the frame of the field theory, we attempt now to give an interpretation of results in terms of macroscopic physics. In the nonhomogeneous system H", both the external physical power associated with the current ***J*** and the power generating a backward flow according to the Le Chatelier principle, can be noncollinear. In this case, the mentioned flows can not completely

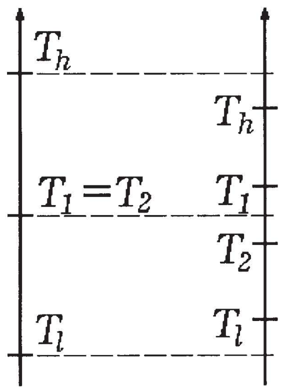


Fig. 4. The temperature distribution in the adiabatic (to the left) and the non-adiabatic (to the right) system H" and in surrounding medium when the system H" is in steady state.

compensate to one another. As a result, the drift and diffusion parts of the current have to flow separately. The detail balance postulate is broken because the polarized system H" cannot attain the equilibrium state. However, in the basis of our arguments there lie equations of the microscopic dynamics which are invariant to time reversibility. Therefore, the Onsager reciprocal relations remain valid.

One can presume that the system H" possesses the cause-consequence symmetry with respect to external temperature and electric fields. Either field causes the thermoelectric effects and induces the other field. The closed electric current circulates without the integral energy dissipation and in this respect is similar to the superconduction current. Nevertheless, as the local energy dissipation takes place somewhere in H", the Hamiltonian of H" does not satisfy the time-reversal invariance. Indeed, according to Eq. (3.31) σ_v consists of two terms, one of them is even and another is odd *vs* time. Recently Liboff [12] and Ramshaw [13] showed that some systems acting as microscopically irreversible ones can have the Gibbs entropy constant in time. The considered system H" is one of them.

Resuming, in this paper we have presented the phenomenological conclusion of conditions of existence of the closed steady-state electric current in the nonhomogeneous medium with respect to electric conductivity medium which is subjected to an outer electrostatic field. Above-mentioned collision of our conclusions with the Second Law may be caused by the fact that a steady-state movement in crossed potential fields has not been investigated. It seems strange that nobody has called attention to this effect when the classic physics was established. Thus, we received new results when researching an unknown object. Starting from this point, we propose to discuss the question of an extension of the Second Law. It is known that entropy of the non-isolated system is decreasing when there is the entropy flux from the system caused by outer powers. Entropy decreasing is necessarily localized *in space*. The Second Law postulates that at any time the entropy density, averaged over a sufficiently great region of space, can not be decreasing.

Similarly, we can treat regeneration of the energy quality and entropy decrease in a space region including the system H", working as a heat pump, as *the localized in time entropy decrease.* Obviously, this process will come to an end when the origin of the electrostatic field will degrade. One can suppose that in this case the meaning of the Second Law may be expressed by the following sentence: In any domain of space the entropy density, averaged over a sufficiently long time interval, can not decrease.

ACKNOWLEDGMENT

We would like to thank Professor A.N. Gorban, Dr. I.V. Karlin, and Professor S.G. Ovchinnikov for stimulating discussions and valuable suggestions. This research is being supported by the International Academy of Energy under Grant No. 0I/Gr/96.

REFERENCES

1. See, for example, S.R. de Groot, Thermodynamics of Irreversible Processes, North-Holland Publishing Co, Amsterdam, 1952.
2. A.A. Barybin, Waves in Thin-filmed Semi-conductor Structures with Hot Electrons, Nauka, Moscow, 1986.
3. L.D. Landau, E.M. Lifshitz, Field Theory, Course of Theoretical Physics, vol. 2, Nauka, Moscow, 1967.
4. Charles Pisot, Marc Zamansky, Mathematiques generales. Algebre - Analyse, Dunod, Paris, 1966.
5. I. Gyarmati, Non-equilibrium Thermodynamics, Springer-Verlag Berlin, 1970.
6. L.G. Loytsanski, Mechanics of Liquid and Gas, Nauka, Moscow, 1987.
7. A.Munster, Chemische Thermodynamik, Akademie-Verlag, Berlin, 1969.
8. S.R. deGroot, P. Mazur, Non-equilibrium Thermodynamics, North-Holland, Amsterdam, 1962.

9. Kerson Huang, Statistical Mechanics, Wiley, N.Y., 1963.
10. S. Pontryagin, Ordinary Differential Equations, Nauka, Moscow, 1974.
11. J.D. Bekenstein, *Phys. Rev. D*, vol 7, pp 2331 (1973).
12. R.L. Liboff, *J. Non-Equilib. Thermodyn.*, vol 15, p 151 (1990).
13. J.D. Ramshaw, *J. Non-Equilib. Thermodyn.*, vol 16, p 33 (1991).

EDITOR'S CHOICE

THE BOLTZMANN DISTRIBUTION

Igor V. Pomerantsev [1]

ABSTRACT

Integral and differential forms of the Boltzmann distribution are derived. The latter, by analogy with the analysis by Maxwell, may be obtained in the absence of the field of forces in two-dimension space. Details of the distribution are refined.

INTRODUCTION

The basis was established by the fundamental definitions of temperature and heat capacity [1,2], which turned out to be erroneous. Inadequate analysis of the Boltzmann distribution is one of the reasons for this approach.

CONCEPTS

Let's carry out a detailed analysis of the Boltzmann distribution. Consider an ideal gas for which the Boltzmann distribution holds, generally written as [3]:

$$n = n_0 \exp\left(-\frac{U}{k_B T}\right), \tag{1}$$

where $k_B T$ is the mean energy of the gas, k_B, is the Boltzmann constant, T is the absolute temperature, U is the potential energy, n is the number of molecules that overcome the potential barrier from the total number of molecules, n_0, residing at U=0.

For one specific case U equals mgh [3]:

$$n = n_0 \exp\left(-\frac{mgh}{k_B T}\right), \tag{2}$$

where m is the mass of a molecule, g is the gravitational constant, h is the height (the current height of the analysis) measured from the ground level. In this particular case the relation for the Boltzmann distribution is known as the barometric formula.

Making use of the law of energy conservation and transformation, Feynman writes [4]:

$$\exp\left(-\frac{U}{k_B T}\right) = \exp\left(-\frac{mgh}{k_B T}\right) = \exp\left(-\frac{v_i^2}{v_B^2}\right) \tag{3}$$

[1] Perm University, Perm, 614600, Russia

Keeping these equations in mind and taking into account the relation for the most probable velocity $v_B \quad \sqrt{2\frac{k_B T}{m}}$, we rewrite (1) and (2) as follows:

$$n \quad n_0 \exp\left(\frac{v_i^2}{v_B^2} \right) \qquad (4)$$

where v_i is the velocity a molecule must possess to reach the level h (the current velocity of the analysis).

The physical meaning of this velocity calls for further explanation which will be given in the course of the analysis.

Consider the functions defined by (2) and (4) plotted on Fig. 1, – is the graphic representation of (4), where n_0 is the number of molecules per unit volume at h=0, i.e., at v_i=0. At the point 1 n_i denotes the number of molecules per unit volume reaching the level h_i, their velocities varying from v_i to infinity. The area enclosed by the curve:

$$n \quad n_0 \exp\left(\frac{v_i^2}{v_B^2} \right)\Bigg|_0^{\infty} \gg n_0 \qquad (5)$$

gives the number of molecules within a column in the field of forces resting on unit area.

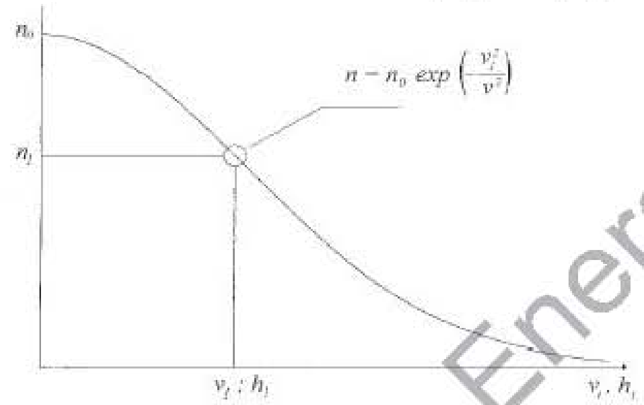


Fig. 1 Integral form of the Boltzmann distribution.

Let's derive the differential form of the Boltzmann distribution (4). Defining the distribution modulus as the absolute value of decrease in the number of molecules with changing height, differentiating and rearranging, we obtain the relation sought:

$$dn \quad 2n_0 \frac{v_i}{v_B^2} \exp\left(\frac{v_i^2}{v_B^2} \right) dv_i \, . \qquad (6)$$

The Boltzmann distribution written in its differential form specifies the number of molecules dn with the velocities from v_i to $v_i + dv_i$. Neither of the forms allows one to calculate the exact number of molecules n having the velocity v_i.

The field of forces differentiates the molecules with respect to the velocities of their motion which they possess initially, in the absense of this field.

This statement implies that the Boltzmann distribution should follow from the analysis of the molecules' distribution on the velocities of their motion. A similar approach was taken by Maxwell [3].

Leaving intact Maxwell's derivation, we arrive at the Boltzmann distribution, if this derivation is applied to two instead of three dimensions.

Let's retrace the classical analysis by Maxwell for two-dimensional space [3]. A point on a plane is chosen where we locate a certain number of molecules with different velocities or only one molecule, which can move with the velocity ranging zero to infinity.

Our task is to find the number of molecules having the velocity *v*. We need the number of molecules *dn* with the velocities varying from *v* to *v+dv*. For the ring-shaped layer on the Fig. 2. $dn_v = \varphi(n;v)$. It is evident that this number is proportional to the total number of molecules *n* and *dv*, i.e.,

$$dn_v = a\, n\, dv\ . \tag{7}$$

From this follows that $a = F(v)$ is the distribution function, or

$$dn_v = nF(v)\, dv \tag{8}$$

It is plain to see that

$$\left.\begin{array}{l} dn_{v_x} = nf(v_x)\, dv_x \\ dn_{v_y} = nf(v_y)\, dv_y \end{array}\right\} . \tag{9}$$

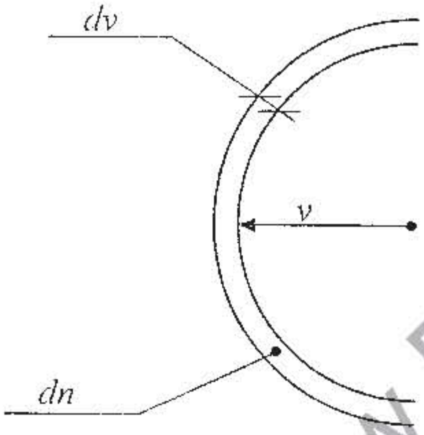


Fig. 2 The range of the velocities for *dn* molecules in a ring-shaped layer.

Since the probability of a complex event is the product of the constituent probabilities, we can write

$$dn_{v_x;v_y} = nf(v_x)\, f(v_y)\, dv_x\, dv_y\ . \tag{10}$$

The concentration of molecules in the ring-shaped layer, defined as $nf(v_x)\, f(v_y)$, is a function of the distance from the origin only

$$v = \sqrt{v_x^2 + v_y^2}\ , \tag{11}$$

therefore

$$f(v_x)f(v_y) = F'\left(v_x^2 + v_y^2\right). \tag{12}$$

Eq. (12) is fitted by the function

$$F'\left(v_x^2 + v_y^2\right) = A^2 \exp\left[B\left(v_x^2 + v_y^2\right)\right], \tag{13}$$

where *A* and *B* are constants need to be determined. Substituting (11), (12) and (13) into (10) we get

$$dn_{v_x;v_y} = nA^2 \exp\left[B\left(v_x^2 + v_y^2\right)\right] dv_x\, dv_y\ , \tag{14}$$

since *dn* from *n* are found in the ring-shaped layer of radius *r*

$$dv_x\, dv_y \sim dv^2 = 2\pi v dv\ . \tag{15}$$

we can write (14) in terms of (15) and (11) as

$$dn_v = 2\pi v n A^2 \exp\left(Bv^2\right) dv\ , \tag{16}$$

or

$$dn_v = 2\pi v n A^2 \exp\left(-Bv^2\right) dv\ . \tag{17}$$

The minus sign is introduced basing on $v \to \infty;\ n \to 0$.

Let's find the relation between *A* and *B*. Integrating (17) with respect to velocity

$$\int_0^{\infty} dn_v = 2\pi n A^2 \int_0^{\infty} v \exp\left(-Bv^2\right) dv \ ,$$

or

$$1 = 2\pi A^2 \int_0^{\infty} v \exp\left(-Bv^2\right) dv \ , \tag{18}$$

since

$$\int_0^{\infty} v \ \exp\left(-Bv^2\right) dv = \frac{1}{2B} \ , \tag{19}$$

therefore

$$B = \pi \ A^2 \ . \tag{20}$$

Further analysis is simplified by noting that in the Boltzmann relations $B = \frac{1}{v_B^2}$, hence

$$A^2 = \frac{1}{\pi v_B^2} \ . \tag{21}$$

Substituting (21) into (17) we obtain

$$dn_B = 2\pi n v \frac{1}{\pi v_B^2} \exp\left(-\frac{v_i^2}{v_B^2}\right) dv = 2n \frac{v}{v_B^2} \exp\left(-\frac{v^2}{v_B^2}\right) dv \ . \tag{22}$$

Differential forms of the distributions (6) and (22) are identical, thus confirming that the field of forces has no effect on the distribution of the velocities of molecules. The field just reveals this distribution.

Now it's time to make the following observation. The Boltzmann distribution in its classical form (2) and (6), respectively, was inferred in the course of the analysis of one-dimensional motion of molecules [3], proceeding from relation

$$nF_x \, dx = dP_x \ , \tag{23}$$

where *n* is the number of molecules under consideration, F_x is the force acting along the *x* axis at a distance *dx*. dP_x is the pressure change along the *x* axis. Equation (22) was deduced from Maxwell's reasoning for the case of two-dimensional space. Consequently, in the two versions considered, the analysis was conducted for different velocities.

It is readily apparent that in the second version of the analysis the real velocities of molecules, uniformly distributed over a plane, were treated; whereas its first version deals with their projections determining the pressure, i.e. for one-dimensional space. The pressure determines the force momentum, which is directed perpendicularly to the surface under pressure.

From this follows that the real velocities and their projections have the same distribution – since (22) and (6) are identical.

The projections of the real velocities of molecules on a normal to a surface under pressure are the current velocities v_i of the analysis of the distributions (4) and (6). The field of forces differentiates these projections *vi* of the zero level. The zero level may be shifted (this is accompanied by a corresponding change in n_0). This act does not alter the general picture of the molecules differentiation according to their velocities of motion.

There is a necessity for joint consideration of the real velocities and their projections. Introduction of this model into the analysis will alter radically the view on the processes studied by physics, chemistry, and partly, mathematics.

CONCLUSION

Integral forms of the Boltzmann distribution

$$n = n_0 \exp\left(-\frac{U}{k_B T}\right), \qquad n = n_0 \exp\left(-\frac{mgh}{k_B T}\right), \qquad n = n_0 \exp\left(-\frac{v_i^2}{v_B^2}\right),$$

and the result of their differentiation

$$dn = 2n_0 \frac{v_i}{v_B^2} \exp\left(-\frac{v_i^2}{v_B^2}\right) dv_i$$

are considered. The latter was also deduced in the course of the Maxwell's classical analysis in the absence of the field of forces for the case of two-dimensional space.

In the latter case, the real velocities of molecules were considered, whereas the former deals with their projections, determining the pressure of a gas. The distributions of the real velocities and their projections are identical. The field of forces does not affect the molecular velocity distribution, it just reveals this distribution.

The analysis conducted proposes a new model for the derivation of the distribution of molecules on the velocities of their motion, which should alter the view on the essence of the processes studied by chemistry, physics, and partly, by mathematics.

REFERENCES

1. J.W. Gibbs, The Scientific Papers, New York: J. Wiley, 1906.
2. J.A. Campbell, Chemical Systems. Energetics Dynamics Structure, San Francisco: W.H. Freeman and Co, 1970.
3. I.C. Kikoin, A.K. Kikoin, Molecular Physics, Moscow: Nauka, 1956.
4. R.P. Feynman, R.B.Leighton, M. Sands, The Feynman Lectures on Physics, Vol 1, Palo Alto, London: Addison-Wesley Publ., 1963.

Editor's Choice

DISCOURSE ON THE RELATIVITY OF SIMULTANEITY

Robert L. Henderson [1]

ABSTRACT

As part of his special relativity, Einstein concluded that the condition of simultaneity of two widely separated events was relative and would not be the same for observers who were in motion with respect to each other. Although this conclusion clearly violated the common-sense concept that any events which occur in the same universal, infinitesimal instant of time are simultaneous for all observers – regardless of their locations or velocities – it was ostensibly validated based on the assumptions which Einstein made in arriving at that conclusion. However, an analysis of Einstein's assumptions made in this regard will reveal that the so-called "relativity-of-simultaneity" concept was ill conceived.

DISCUSSION

In his paper entitled "On The Electrodynamics of Moving Bodies" published in 1906, in which the principles of special relativity were first set forth, Einstein proposed a thought problem which led him to the conclusion that the condition of simultaneity of widely separated events was not the same for all observers, but rather was dependent on the velocity of the observers who witnessed the events. Although this conclusion clearly violated the common-sense concept that any events which occur in the same universal, infinitesimal instant of time are simultaneous for all observers - regardless of their locations or velocities - it was nevertheless assumed to be validated based on Einstein's assumptions concerning the velocity of light, and his assumed conditions required for the synchronization of clocks. However, an analysis of Einstein's assumptions made in this regard in the aforementioned paper will reveal that the "relativity-of-simultaneity" concept was ill conceived, as follows:

1. As a fundamental concept of special relativity, Einstein assumed that the velocities of all light beams were a constant value c in every direction with respect to all reference frames which were either at rest or moving with uniform linear motion. This concept was referred to by Einstein as "The Principle of the Constancy of the Velocity of Light."

2. The Principle of the Constancy of the Velocity of Light was then modified by considering the velocity of light as it would be determined by observers in two separate reference frames that were moving with uniform linear motion with respect to each other. Under these conditions, the Principle was assumed to manifest itself in two different ways, as follows:

> 2.a. Assume there are two observers, one in a reference frame that is arbitrarily designated as a stationary frame, and the other in an overlapping, moving frame that has a velocity v in the west-to-east direction with respect to the stationary frame. Let both observers now determine the velocities of two light beams that are traveling in opposite directions through both reference frames along their west-east axes, one beam traveling west to east and the other beam east to west.

[1] 10529 W. Campana Dr., Sun City, AZ 85351

2.b. Now, the stationary observer – because of the Principle of the Constancy of the Velocity of Light as set forth in paragraph 1 – will find the velocities of both beams to be the value c within his reference frame. Likewise, the moving observer – also because of the Principle of the Constancy of the Velocity of Light – will find the velocities of those same two beams to be the value c within his reference frame.

2.c. However, let the stationary observer now contemplate what the velocities of the light beams should be in the moving frame. Because the moving frame has a velocity v with respect to the stationary frame, and since the light velocities were the value c in the stationary frame, it was assumed that the stationary observer must find their velocities with respect to the moving frame to be c - v in the west-to-east direction, and c + v in the east-to-west direction: a simple matter of vector addition. It was therefore assumed that these c - v and c + v velocities also existed in the moving frame!

Let us now clarify the conditions that were developed - through Einstein's logic – in the previous three paragraphs 2.a., 2.b., and 2.c. Although the Principle of the Constancy of the Velocity of Light assumed that the velocity of light would be c in every direction with respect to all reference frames either at rest or moving with uniform linear motion, Einstein actually believed that light velocities could either be c in opposite directions within a moving reference frame, or c - v in one direction and c + v in the other, depending only on which line of reasoning one used to arrive at the velocities! Although this dualistic condition is at once seen to be impossible, it is nevertheless a fundamental element of Einstein's special-relativistic logic.

3. It was also assumed that two clocks which were located some distance apart could only be synchronized if the velocity of light was the same in both directions between the clocks: Einstein apparently believed it was necessary for the time interval required for light to travel from the first clock to the second be the same as the time interval required for light to travel from the second clock to the first in order to synchronize the clocks. Einstein assumed this requirement for the synchronization of clocks to be true "by definition."

(However, it should at once be noted that this assumption is not valid. Although it is true that clocks can be synchronized if the velocity of light is the same in both directions between clocks, it is not necessary for it to be the same. Clocks that are separated can be synchronized utilizing any convenient method of signal transmission between the clocks: the only requirements are that the distance between the clocks, and the velocity of the transmitted synchronizing signal be known. Furthermore, the signal velocity need only be known in one direction: that being in the direction from the master clock to the slave clock. From the known distance and the known synchronizing-signal velocity, the transmission time interval can be computed and the clocks synchronized.)

4. As a consequence of the Principle of the Constancy of the Velocity of Light as interpreted in paragraph 2 above, whereby light velocity in a moving reference frame could either be c in both directions, or c - v in one direction and c + v in the opposite direction at the whim of an observer in a stationary frame, coupled with the foregoing equal-light-velocity requirement for synchronizing clocks, it was concluded that clocks which were synchronized in one reference frame would not be synchronized if viewed from another reference frame which had a velocity with respect to the first frame. This conclusion in turn led to the "relativity-of-simultaneity" concept, which was arrived at as follows:

Let us assume a stationary reference frame within which are located two clocks separated from each other along the west-east axis, and let us assume the clocks have been synchronized with each other, which is permissible according to Einstein's criteria since the velocity of light is assumed to be c in both directions between the clocks in a stationary frame.

Let us next assume that two events take place in the stationary frame, one in the vicinity of the first clock and the other in the vicinity of the second clock. Let us further assume that observers at each of the clocks note that the events take place at the same instant of local time as indicated on each of the clocks. Therefore, because the clocks are synchronized, it is assumed that the two events are simultaneous since they both occurred at the same synchronized instant of time.

Let us now introduce a moving reference frame that has a velocity v in the west-to-east direction with respect to this stationary frame. Let us further assume there are two observers in the moving frame who are located along the west-east axis the same distance apart as the two clocks in the stationary frame, and that each observer has a clock at his location which is synchronized with its counterpart in the stationary frame. Let us further assume that the two clocks are along-side their counterparts in the stationary frame when the two aforementioned events take place. Now, although common sense dictates that the two observers in the moving frame should also find the events to be simultaneous, according to Einstein, they would not, for the following reason:

Although each of the clocks in the moving frame was assumed to be synchronized with its counterpart in the stationary frame, they would not be in synchronism with each other in the moving frame because of Einstein's convoluted reasoning that light velocity would not be c in both directions between the clocks (which Einstein assumed was a requirement for synchronization), but rather would be c - v in one direction and c + v in the opposite direction! Therefore, since their clocks would not be synchronized in the moving frame, the two observers would not read identical local times on their clocks when the events take place, and hence would not find the two events to be simultaneous in their moving frame.

Based on the foregoing reasoning, then, it was concluded that events which were simultaneous in one frame of reference would not be simultaneous when viewed from any other frame of reference which was in motion with respect to the first frame: a conclusion which came to be known as the "relativity-of-simultaneity" concept.

Now, the fallacy in this line of reasoning is readily apparent from two different viewpoints. First, if one applies the Principle of the Constancy of the Velocity of Light in the manner it was originally conceived (as in paragraph 1 above), the velocity of light becomes c in all directions in both reference frames: therefore, the clocks in both frames become properly synchronized and the events are simultaneous in both frames.

And secondly, it is simply a rational fact that any events which occur in the same universal, infinitesimal instant of time are simultaneous to all observers, regardless of the observer's locations or relative velocities. This is a fundamental, common-sense truth against which one must judge the validity of any theory which attempts to show that the condition of simultaneity is relative. And in the case of special relativity, the irrationalities which render the relativity-of-simultaneity concept invalid are Einstein's absurd assumptions that light velocity within a moving reference frame can have either the same velocity c in opposite directions, or c - v in one direction and c + v in the other; and that light velocity must be the same in both directions between clocks in order for the clocks to be synchronized. It should be clearly understood that the relativity-of-simultaneity thought problem is irrational and has no significant meaning insofar as synchronizing clocks, or determining the nature of simultaneity, is concerned.

Furthermore, in evaluating the various hypotheses contained in this thought problem, it should be understood that even the relativistic concept that the velocity of every light beam is the same value c with respect to every moving reference frame is irrational since it violates the common-sense principal of the vector addition of velocities. (It should also be noted that the FitzGerald contraction of length and Lorentz contraction of time phenomena – which are assumed to operate within moving reference frames in such a manner as to make the velocity of light the same value c in all moving reference frames – will not perform that function.) However, by slightly altering the relativistic concept so as to say that the velocity of light is the same value c with respect to every moving physical body (such as the earth), when measured in the immediate vicinity of the body, the "constant-velocity" concept becomes rational. With this interpretation of the nature of light, by simply incorporating the rational concept of a light-conducting medium which is maintained in equilibrium about each physical body due to the physical interaction of each body with the medium (analogous to the condition in which the earth's atmosphere is found to be in equilibrium about each moving hot-air balloon), one is able to rationally conceive not only how the velocity of light could be the velocity c with respect to all physical, moving reference frames, but also how the velocity of light would change as it propagated from one physical, moving reference frame to another, thereby permitting observers in all such moving reference frames to not only synchronize the clocks within each frame, but to synchronize the clocks within each moving reference frame with the clocks within every other moving frame.

Based on the foregoing analysis, then, it should be understood that only by acknowledging the existence of the universal light-conducting medium can rationality be brought to the problem of clock synchronization. Thus, the condition of simultaneity of widely separated events can be correctly determined within every moving reference frame. **Furthermore, by hypothesizing the medium as an intense "universal energy field" (UEF) composed of a dense concentration of an infinite number of "elementary" particles (i.e., the smallest possible particles, which possess only the property of mass, or inertia: they have no gravity) in high velocity random motion, colliding with each other and rebounding with perfect elasticity (which is an inherent property of the collisions of elementary particles) an innumerable number of times per second in a manner similar to that of the atoms which comprise the earth's invisible, energetic atmosphere; it would also provide the missing ingredient required to resolve substantially *all* the major problems yet facing the physical sciences.**

This concept would constitute a medium capable of conducting waves and generating forces: a medium from which to develop the rational explanations for the phenomena of light, gravity, nuclear energy, the origin of matter, the nuclear binding force, electric and magnetic field forces, radioactivity, the Higgs boson (which is the elementary particle of the UEF), the Higgs field (which is the UEF itself), the missing mass of the universe (which–again–is the UEF itself), and the macroscopic configuration of the universe as well. In addition, it would provide the medium required to generate both the "zero-point," or "vacuum" energy, and the compressive force about every point in space called the "cosmological constant," which are the two hypothesized phenomena required to provide quantum mechanics with its long-sought, rational foundation.

OPERATING THE LENT-1 TRANSMUTATION REACTOR: A PRELIMINARY REPORT

By Hal Fox and Shang-Xian Jin

ABSTRACT

The Low-Energy Nuclear Transmutation (LENT-1) reactor can transmute thorium into smaller mass elements. This transmutation process differs markedly from the natural decay of thorium-232 into lead-208. Using a small amount of thorium nitrate dissolved in distilled water as the electrolyte, the LENT-1 reactor will transmute essentially all of the thorium into small mass elements in thirty minutes processing time. Considerable development work is required to understand the role of reactor parameters in producing various transmuted smaller mass elements.

A. INTRODUCTION

Most of the current models of nuclear reactions require that high energy be used to cause nuclear reactions, except for the decay of naturally radioactive substances such as thorium and uranium. Nearly all of the nuclear experimental data has been obtained by experiments based on nuclear reactors or using high energy particle accelerators. The study of nuclear reactions in or on the surface of a metal lattice is relatively new. Two international conferences on Low-Energy Nuclear Reactions have been held and the proceedings published in the *Journal of New Energy* [1,2]. Several important papers have reported on experiments in which low-energy nuclear reactions are observed. This paper reports on the results that have been achieved by various workers using the Low-Energy Nuclear Transmutation (LENT-1) reactor.

The LENT-1 reactor consists of a cylindrical electrode and a disk-shaped electrode positioned on the interior of the cylindrical electrode. See Fig. 1 for an outline drawing of the LENT-1 reactor. Both electrodes are made of a special metal (e.g. zirconium). The reactor includes strong stainless steel end plates and bolts together with Teflon™ seals. When properly assembled, the reactor is a pressure vessel capable of processing about 20 to 30 ml of solution. Some of the variable parameters are the following:

- Pressure
- Temperature
- Electric Potential
- Electric Current
- Input Electrical Power Waveform (d.c., a.c., pulsing, etc.)
- Electrical Parameter Changes During Processing
- Electrolyte Conductivity
- Processing Time
- Electrode Conditioning

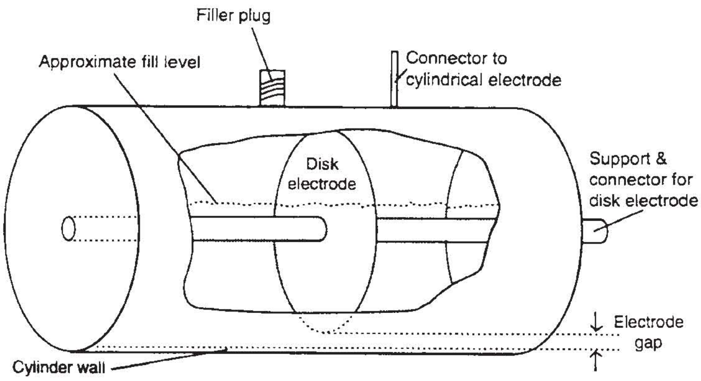


Fig. 1 Cut-away of LENT-1 Reactor

In laboratory experiments over the past three years, the following parameter ranges have been selected or observed: Pressure from 1 to 25 atmospheres; Temperatures from 70 F to 400 F; Electric potential from 25 to 600 volts; Electric current up to 5 amperes; Waveforms normally either a.c. or d.c.; Electrolyte resistance from 2 to 500 ohms; Processing time from 30 minutes to six hours; and a variety of electrode conditioning, usually by anodizing, to obtain a high-resistance oxide layer. Experimental results vary widely with changes in parameters. Over three years of experimentation has resulted in useful operating protocols that are highly reproducible in terms of transmuting thorium-232 into lower-mass elements. Elements and amounts of elements produced by transmutation vary significantly from one experiment to another. However, it is expected that exact control of operating parameters will produce essentially the same transmutation results in terms of elements transmuted and amounts of such elements produced.

Low-energy nuclear reactions constitute a new and potentially highly-valuable branch of physics. The theory must follow the experimental results as there are no widely recognized theories that explain all of the experimental observations. This branch of physics is new and will be met with a high degree of skepticism by many physicists. Moderate skepticism is acceptable and expected for all dramatic new discoveries. Excessive skepticism or denial of replicated experimental results by proclaimed authorities must be treated in the same manner as previous declarations against heavier-than-air machines, atomic energy, data-processing by machines, and space flight. All of these new discoveries were condemned by self-proclaimed experts.

Replication of experiments with the LENT-1 reactor have been performed by several different groups. Where the protocols are precisely observed, thorium is transmuted into other elements within a thirty-minute processing period. The following is an excellent definition of a scientific fact: "A scientific fact is the close agreement of a series of observations of the same phenomena." With this definition, it can now be stated that low-energy transmutation using the LENT-1 is an scientific fact. However, workers in this new technology will welcome published reports on further replications or for experimental additions to the currently-available experimental data. The purpose of this paper is to provide additional information obtained from a series of recent (September-October 1997) multiple experiments (over a dozen) using the LENT-1 reactor. In addition, this paper provides some important tutorial information.

B. THE USE OF THORIUM NITRATE WITH LENT-1

The element thorium has 26 known isotopes, none of which are stable. However, Thorium-232 is the isotope of thorium that is found in nature. This **almost stable** isotope has a half life (the time it takes for one half of the element to transmute into other elements) of 1.4×10^{10} years or 14,000,000,000 years. Although this thorium isotope is considered to be radioactive, it is only mildly radioactive and can be used in normal laboratories without having to operate under the regulations of the Nuclear Regulatory Agency that are prescribed for handling higher-level radioactive materials.

Thorium Nitrate has the chemical compound symbols of $Th(NO_3)_4 \bullet 4H_2O$. It is labeled by the supplier as Radioactive and Oxidizer. Class 7 (Primary Risk) and Class 5.1 (Secondary Risk). 1 Type A Package x 1.2×10^{-5} Curie. Cargo Only Aircraft! This compound is available from Johnson Matthey, Precious Metals Division, 2001 Nolte Drive, West Deptford, NJ 08066. (609)384-7000. Fax (609)384-7282.

Thorium Nitrate is readily soluble in water. For careful experiments, only distilled water should be used if you intend to make **before-** and **after-processing** measurements of elements with a parts-per-million accuracy. Water that is not distilled may carry various elements in parts per million quantities that will distract from the accuracy of determining what elements are being produced during transmutation experiments.

Thorium Nitrate, $Th(NO_3)_4 \bullet 4H_2O$, was chosen for testing with the LENT-1 Kit because it is **very soluble** in water. Thorium, in nature, consists of about 100% ${}_{90}Th^{232}$ which is mildly radioactive with a half life of 1.4×10^{10} years. The entire chain of transmutation events in the natural radioactive decay of thorium is:

$_{90}Th^{232}$ --> $_{88}Ra^{228}$ --> $_{89}Ac^{228}$ --> $_{90}Th^{228}$ --> $_{88}Ra^{224}$ --> $_{86}Rn^{220}$ -->
$_{84}Po^{216}$ --> $_{82}Pb^{212}$ --> $_{83}Bi^{212}$ --> $_{84}Po^{212}$ or $_{81}Tl^{208}$ --> $_{82}Pb^{208}$.

If the thorium nitrate were absolutely 100% pure and freshly constituted from chemically-pure thorium, one could assume that there would be no decay products. However, the radioactive decay products are continuously produced by the **radioactive decay** of thorium. The amount of each daughter product in a prepared sample is a function of previous purity of the thorium and the shelf life of the product. The following table provides information on half-lives, decay modes, and energies of emitted particles in the thorium decay series:

TABLE I. THORIUM DECAY DAUGHTER PRODUCTS

Element	Half-Life	α (MeV)	ß (MeV)	γ (KeV)
Thorium-232	1.4 x 10^{10}y	4.01, 3.95	--	59(w)
Radium-228	5.76 y	--	.039, .015	14(w)
Actinium-228	6.15 h	--	1.2, 2.1	911, 969, 338
Thorium-228	1.91 y	5.42, 5.34	--	84, 216, 132, 166
Radium-224	3.66 d	5.69, 5.45	--	240
Radon-220	55.6 s	6.29	--	550
Polonium-216	0.145 s	6.78	--	805(w)
Lead-212	10.6 h	--	.331, .569	239, 300
Bismuth-212	60.6 m	6.05	2.25	40, 727
Polonium-212	298 ns	8.78	--	--
Thallium-208	3.05 m	--	1.8, 1.28, & 1.52	2615, 583, 511
Lead-208	stable			

SOURCES: Lapp et al., [3], Hunt [4].

RADIOACTIVE DECAY PRODUCTS

When a thorium nucleus decays (transmutes into another element) the general process is for the Thorium-232 to emit an **alpha particle** (essentially an ionized helium-4 nucleus). This alpha particle emission is accompanied by the emission of a **gamma ray**. The gamma ray has a specific energy level of 59 Kev or 59,000 electron volts. A gamma ray is an energetic photon -- quantized energetic electro-magnetic radiation. Note that in the above table, seven of the transmutation events emit alpha particles and five emit beta particles (essentially the emission of an energetic electron). Note also that all of the transmutation events in the natural decay of thorium emit gamma rays except for Polonium-212.

One can purchase various types of sensors that will measure alpha, beta, and gamma emissions. **It is important to note that naturally radioactive thorium will emit all three: alphas, betas, and gammas.** It is also important to understand that the natural radioactive decay of thorium (and of uranium) is a process that gives off energy carried by the kinetic energy of the daughter elements and by the alpha, beta, and gamma radiation. However, this is not the process that occurs in the artificial transmutation of thorium in the LENT-1 reactor! The nuclear processes in the LENT-1 reactor are **not** an increase in the natural decay rate of thorium. The normal chain of radioactive decay of thorium will continue, of course, in the reactor as the thorium is being processed. This normal radioactive decay will continue with any thorium remaining after the processing by the LENT-1 reactor. If operated by the established protocols, there will be only a very small amount of thorium remaining after the standard thirty minutes of processing time.

The type of nuclear reaction that is believed to take place in the LENT-1 reactor is a process by which one or more protons (ionized hydrogen obtained from the water - H_2O) are injected into the nuclei of the thorium atoms **which have been transported onto or close to the surface of one of the electrodes in the reactor.** Normally these reactions take place on the cathode, however, where a.c. is used it is expected that these reactions take place during the cycle when each electrode is temporarily the cathode. The addition of one or more protons to a thorium nucleus causes the nucleus to become immediately unstable. By fusion of the proton and thorium, Protactinium-233 can be produced. Pa-233 decays to U-233 and the U-233 decays by alpha emission to Th-228 which decays by alpha emission to Ra-224 etc. However, it is more likely that the thorium will fission due to the sudden instability by being injected with one or more protons. This disruption of the stability of the thorium nucleus can produce fission of the nucleus into two or more other elements. While the natural decay of thorium ends up as a stable lead isotope (Pb-208, the predominant isotope of lead found in nature), it is expected that the fission of thorium will be into elemental masses that are considerably less massive than lead. As an example, if the thorium were to be injected with 2 protons, the thorium could split into two equal parts, then one would expect to get two nuclei of palladium. More often unequal fission products are expected. Because heavy elements like thorium are **neutron rich** (having a higher ratio of neutrons to protons as compared to the lower mass elements) some unstable isotopes of palladium may be expected (such as Pd-117). These isotopes generally have short half lives and decay into other elements such as silver, cadmium, indium, or tin by beta emission. The beta emission process occurs as a neutron in the nucleus emits an electron and becomes a proton. This is one way that the excess neutrons are consumed. An alternative would be the release of neutrons. Fortunately, the nuclear reactions that are observed are beta emissions rather than the emission of neutrons.

Nuclear reactions are complex but not complicated. A study of a chart of the nuclides will show that unstable elements below the mass of lead will normally decay (transmute) into other elements by beta decay. Therefore, the newly-produced element has one less neutron and one more proton. The study of nuclear radiation (often resulting from studies of the results of nuclear reactions in the fuel pellets in a nuclear power plant) has produced a great deal of information as to what elements are produced from the fissioning of uranium. In general, nearly all of the elements produced by the fissioning of heavy elements (such as U-235) are either stable or are radioactive and exhibit further transmutation by **beta decay!** However, the natural radioactive decay events often produce alpha particles. Those who proclaim that the LENT-1 reactor must produce neutrons need to be aware of the extensive experimental evidence, especially with reactors of the class of the LENT-1.

It is true that heavy elements are **neutron rich**, that is, these heavy elements have a higher ratio of neutrons to protons as compared with lower-mass elements. **However, these neutrons do not have to be emitted under nuclear fission processes.** Nature has decreed that these excess neutrons can be transmuted into protons in the nucleus by the emission of electrons. The end result is important in the determination of the transmutation results in the LENT-1 reactor. Please note that the elements produced by transmutation in the LENT-1 reactor are not always expected to be stable elements. The experimental evidence is that immediately after the processing of thorium in the LENT-1 reactor, one or both of the reactor electrodes are radioactive (meaning that the electrodes emit some combination of alpha, beta, and gamma emissions).

In the processing of the thorium-laden electrolyte, the measurements of emission made using a Geiger counter are as shown in the following table:

TABLE 2. Before & After Geiger Counter Readings from Electrolyte
Table Data in Counter per Minute

	Sample B	Sample C	Sample D	Sample E
Before Processing*	39 ± 17	43 ± 17	41 ± 17	41 ± 17
After Processing	Background	Background	Background	Background

* Counts after subtracting background.

Those who are somewhat knowledgeable in electrochemistry would immediately declare that the thorium has been removed from solution and plated out of solution onto the electrodes. This concept is not unreasonable. However, alternating current, as used with the specific protocols for the operation of the LENT-1 reactor is not expected to be effective in plating thorium onto the reactor electrodes. **Here is how to measure whether the thorium has plated onto the electrodes:**

TEST 1. The naturally radioactive thorium emits alpha and gamma particles. The daughter products emit alpha, beta, and gamma radiation. The lower-mass fission products from thorium produced in the LENT-1 reactor are expected to be stable or only emit beta active isotopes, if the thorium is totally transmuted to the low-mass isotopes. Because of the large size of the alpha particles (a helium-4 nucleus consisting of two neutrons and two protons) any emitted alpha particles can be stopped by one to a few sheets of paper. The smaller beta particles (essentially energetic electrons) can penetrate the barrier of a few sheets of paper. Using an alpha sensor (detector) and a beta sensor (detector) the thorium emissions will have both alpha and beta emissions. The expected nuclear fission products that cause the electrodes to become radioactive are expected to produce mainly beta emissions. (However, if the thorium and the daughters are not totally transmuted to low-mass isotopes, or the thorium and a proton fuse into protactinium (Pa^{233}) and which decays into lower mass isotopes, then there can be emissions of α, β and γ.)

TEST 2. The naturally radioactive thorium has a very long half life of about 14 billion years. If the radioactive emissions from the electrode are due solely to thorium being plated onto the electrode, the degree of radioactivity from the electrode will not change with time over a few days or even a few years. **If the radioactive emissions from the electrode are due to beta decay then it is expected that these emissions will decrease with time of a few hours to a few days.** Depending on the elements being produced by transmutation in the LENT-1 reactor, the half-life of these elements (beta emitters) will be a combination of the various elements produced. In some of the experiments that have been done, the average time for the reduction of the beta emission from the electrode **after processing** ranges from an estimated 25 hours to 100 hours. This rapid decrease in radioactivity cannot be due to the plating of thorium onto the electrodes. See Fig. 4.

Because of the large number of parameters that can have different values, there may be cases where thorium is plated onto the electrodes. There may be cases where there is a combination of plating and nuclear reduction of thorium. And there may be cases where protactinium is produced with its resultant alpha particle emission. The above tests will help to determine to what extent the thorium is present on the electrodes. However, to determine just what elements are on the electrode(s) gamma-ray spectroscopy can be used.

C. GAMMA-RAY SPECTROSCOPY

The use of gamma-ray spectroscopy is an appropriate choice of instrumentation to use with these experiments because all of the daughter products of thorium emit gamma rays except for polonium-212 which has a half life of 298 nanoseconds. **The assumption is made that the total emission of gamma-rays is an acceptable measure of the amount of radiation in a sample prior to processing. It is further assumed that the same gamma-ray total emissions after processing is an acceptable measure of radioactivity.** If we observe an experimental procedure in which the radiation of container, electrodes, and gaseous effluent (if any) are the same before and after processing, then we assume that the changes in radioactivity of the electrolyte is an appropriate measure of the before and after amount of radioactivity. (Often, the short-term radioactivity of the electrodes has decreased to near background by the time that samples are processed by local chemical laboratories.) You may want to submit samples of **before-processing** and **after-processing** to laboratories with suitable gamma-ray spectroscopes. Each element emits gamma rays having different energy levels. By using instrumentation that can measure the various energy levels one can determine what elements are present. Such equipment, if properly calibrated and operated, can be used to determine which elements are present in the **before-** and **after-processing** samples.

The gamma-ray spectroscope can be used immediately after processing to observe the emissions from the electrodes. If the spectroscope is sufficiently sensitive it will be possible to determine exactly which isotopes are decaying by beta decay. A complete low-cost spectroscope can consist of a sodium iodide detector, a power supply, a multi-channel analyzer (mounted on printed-circuit boards that go into a personal computer) and the proper computer software. Such equipment can be obtained for about $5,000. This type of equipment will be very helpful for the LENT-1 experimenter. For better spectroscopes, cryogenic cooling and vacuum systems are required. These features add an estimated $15,000 to the spectroscope.

If the LENT-1 reactor is properly used, the entire thirty-minute process is operated within a sealed reactor so that no gaseous effluent is released during processing. However, there may be some gaseous elements such as helium, argon, chlorine, etc. that may be a by-product of some nuclear transmutations. Such gases may be released when removing the filler plug from the reactor. There is no expectation that any thorium would be lost with the release of such a gaseous effluent. Using suitable professional laboratory equipment (such as a gamma-ray spectroscope), the electrodes can be examined to determine what elements are present on the electrode itself. Only a small amount of thorium has been determined to be a part of the eroded electrode that is the result of running a thirty-minute experiment.

In LENT investigation the most important measurement may be EDX (Energy Dispersive X-ray Spectroscopy) or ICP/MS (Inductively Coupled Plasma/Mass Spectrometry) analysis combined with SIMS (Secondary Ion Mass Spectrometry), and with AES (Auger Electron Spectroscopy) for determination of elements and their isotopes.

D. PRELIMINARY DATA FROM EXPERIMENTS

The LENT-1 reactor was used with a variable power supply in efforts to replicate the experimental results of the transmutation of thorium. The basic experimental equipment used was a power supply which allows for the selection of either a.c. or d.c. power from ten to five hundred volts. These particular experiments used the LENT-1 reactor obtained from the Cincinnati Group; the power supply; and a computer-acquisition system for counting and storing data from a Geiger Counter. The entire equipment used for these experiments cost less than $5,000 including $3,000 attributed to the cost of the LENT-1 Kit. Therefore, even small companies can participate in the development of this new technology.

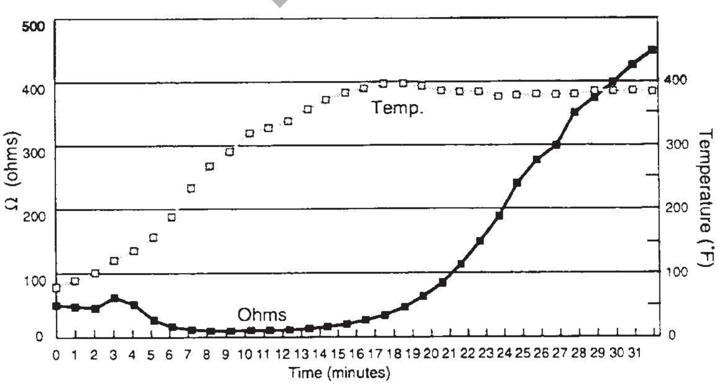


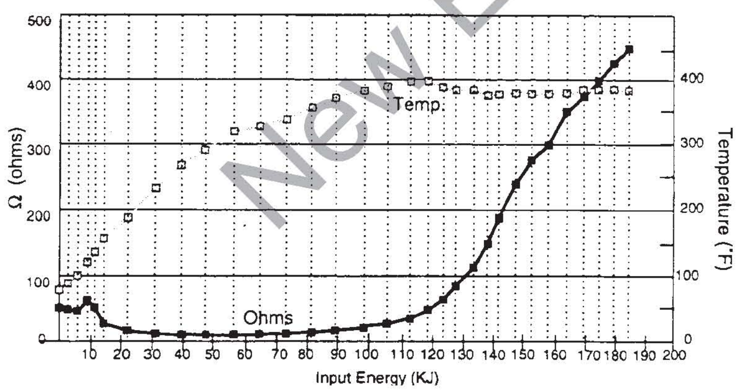
Fig. 2 The Variation of the Resistance & Temperature of the LENT-1 cell with processing time.

The LENT-1 reactor consists of a cylindrical electrode with a disk-shaped inner electrode so that the electrical current flows from the disk to the inside of the cylindrical electrode. The plane of the circular-disk electrode is perpendicular to the axis of the cylindrical electrode. The reactor is operated with the axis of the cylindrical electrode parallel to the laboratory bench top. The reactor is filled about half full of a mixture of thorium nitrate and distilled water. See Fig. 1 for an outline drawing of the reactor.

The resistance of this special electrolytic cell is a function of the amount of thorium nitrate, the spacing between the disk electrode and the cylindrical electrode, the temperature of the electrolyte, and the chemical changes that are caused in the electrolyte during processing. The resistance of the cell changes dramatically, as computed by the voltage divided by the current, during the processing time. Fig. 2 shows a plot of the cell resistance (and cell temperature) with processing time.

At the initiation of the processing of the thorium solution about 100 watts of power is introduced into the reactor. This power input causes a gradual rise in temperature of the reactor as measured by a digital thermometer with a surface sensor affixed to the outside of the cylindrical electrode of the reactor. Following the prescribed protocols provided with the LENT-1 Kit, the voltage is increased by ten-volt steps as the current decreases (the internal resistance of the electrolyte increases). Therefore, the experiments are operated using an approximately constant power input. After about fifteen minutes of operation the temperature of the electrolyte stabilizes at about 375 F ± 50 F. One may expect that the nuclear reactions would cause an extreme amount of heat to be produced. However, the complexity of nuclear reactions that appear to be present can be a combination of exothermic (heat producing) and endothermic (heat using) reactions.

From about fifteen to thirty minutes of the processing time, the resistance of the electrolytic cell strongly increases. This experimental measurement suggests that the thorium ions are being removed from solution faster than other chemical ions are added to the solution. The data from the same experiment as shown in Fig. 2 has been plotted against the input energy to the reactor. See Fig. 3. There is a noticeable difference between the curves in the two figures 2 and 3. Both the temperature rise curve and the rise in the cell resistance, when plotted against total energy input, have portions that are relatively linear. This observation suggests that, as expected, the temperature of the cell is roughly a linear function of the input energy for the first ten minutes of operation. Also, the rapid increase in cell resistance is quite linear after about 20 minutes of operation. In one experiment, the cell was operated for an additional thirty minutes. The voltage was controlled to keep the temperature of the reactor about constant (as a safety precaution). The result was that a continuous 80 watts of electrical power was fed into the cell. Both temperature and cell resistance remained essentially constant. The explanation is that the cell, at temperatures near 400 °F, is radiating all of the 80 watts of input power. This measurement is important for our evaluation of where the input energy is being used and as a basis for a later determination of the amount of energy it takes to drive the desired nuclear reactions.

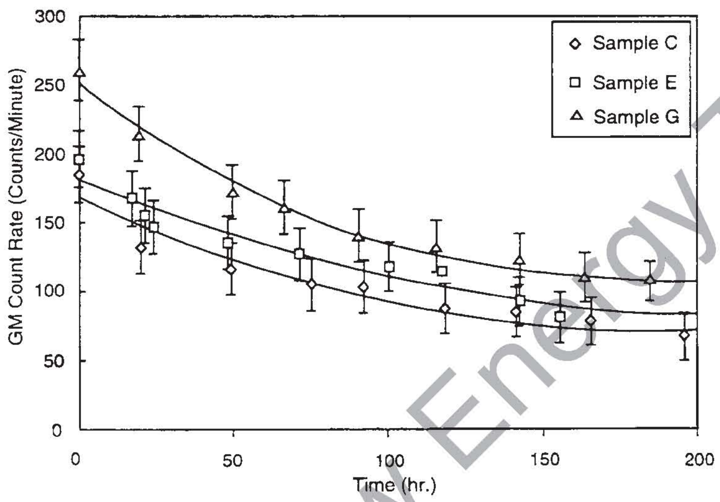


As inferred by the temperature of the reactor, the internal pressure of the cell ranges from atmospheric pressure at the start to as high as more than twenty atmospheres (about 0 to 400 psig). If proper assembly and operation of the cell has taken place, the steam produced from the heating of the electrolyte is contained within the cell. **Note: due to the possibility of the generation of very high pressures, this experimental apparatus should be placed behind a barrier in the case of any fracture of the reactor! THIS IS NOT A TOY AND SHOULD BE USED ONLY BY SAFETY-AWARE TRAINED EXPERIMENTERS.**

BEFORE & AFTER RESULTS

The electrolyte, the disk electrode, and the inner surface of the cylindrical electrode were measured for radioactive emanations by using a Geiger counter. The **before-processing** measurements of the electrodes were essentially at background. The initial thorium solution showed counts considerably above background. The **after-processing** measurements showed dramatic reduction of radioactivity of the electrolyte **and dramatic increase of the radioactivity on the surface of the electrodes.**

However, measurements made by placing the disk electrode near the sensor of the Geiger counter showed that the radioactivity of the electrodes is dramatically reduced, apparently on an exponential basis, from about three times background to about one-third above background, over a period of less than 100 hours. See Fig. 4 for typical radiation measurements over a 200-hour period. Note that the combined half-life of the elements that are producing the radioactive emanations ranges from about 50 to 100 hours in different experiments. Some of the disk electrodes were measured using a borrowed alpha detector. A low level of alpha particle emission was noted. The alpha emissions are believed to be a combination of some small amount of thorium and some small amounts of protactinium and its daughter products.



A careful inspection of a Chart of Nuclides will show that any reasonably expected fissioning of a heavy element will result in smaller elements. However, the elements produced can be expected to be among those hundreds of short-lived elements that are "radioactive", usually with short-half lives where the element is transformed into another element by beta-emission.

The **before-processing** and **after-processing** samples of the electrolyte were submitted for ICP mass spec analysis. The most notable change in the 12 elements selected for analysis was the dramatic decrease (by over 95%) in the amount of thorium in the electrolyte. Due to the relative high costs of analytical services, a complete elemental analysis has not as yet been accomplished. A commensurate number of newly-produced elements has not, as yet, been determined. Copper and silicon were noticeably increased in the solution. It must be recognized that many of the elements that could have been produced could combine with electrolysis by-products, notably H and O ions, to produce compounds that are not soluble in the aqueous electrolyte. Of course, the change in ion content of the electrolyte is evident by the dramatic increase in the resistance of the electrolyte (Fig. 2 and Fig. 3).

E. SUMMARY

The LENT-1 is one of an increasing number of devices that exhibit transmutation of elements. These nuclear reactions have been replicated by a few investigators, however, more independent replications and more extensive post-processing analysis will be required to convince skeptics of the reality of this new technology. Working with thorium is an advantage because thorium does not require a "hot lab" environment. Sufficient short-term radioactivity of transmuted products is produced in the LENT-1 which is an advantage to track the nuclear reactions that modify neutrons into protons by beta emission. Typical data indicates that the bulk of the nuclear reactions occur within about a fifteen minute time period of the thirty-minute typical period that transmutes most of the thorium from the electrolyte. Due to the nature of the nuclear reactions, considerable chemical and isotopic analysis will be required by serious experimenters.

ACKNOWLEDGEMENTS

Data for this preliminary report has been provided by permission of **Trenergy, Inc.**, the Utah corporation that funded the experimental investigation. Mr. Stan Gleeson of "the Cincinnati Group" has furnished the LENT-1 reactor. Dr. S-X. Jin has been responsible for obtaining this basic (and preliminary) data.

REFERENCES

1. Hal Fox, editor, "Proceedings of the First Conference of Low-Energy Nuclear Reactions," (Texas A&M, June 19, 1995) published in *Journal of New Energy*, vol 1, no 1, Jan 1996.
2. Hal Fox, editor, "Proceedings of the Second Conference of Low-Energy Nuclear Reactions," (College Station, Texas, Sept 13-14, 1996) published in *Journal of New Energy*, vol 1, no 3, Fall 1996.
3. R.E. Lapp, H.L. Andrews, Nuclear Radiation Physics (1992), Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
4. S.E. Hunt, Nuclear Physics for Engineering and Scientists (1987), Ellis Harwood, Ltd., Market Cross House, Cooper Street, Chichester, West Sussex, P019 1EB, England.

Important references for further information: **The papers marked with (*) are especially pertinent.**

* Robert Bass, Rod Neal, Stan Gleeson, & Hal Fox, "Electro-Nuclear Transmutation: Low-Energy Nuclear Reactions in an Electrolytic Cell," *Journal of New Energy*, vol 1, no 3, Fall 1996.
* Ken Shoulders and Steve Shoulders, "Observation on the Role of Charge Clusters in Nuclear Cluster Reactions," *Journal of New Energy*, vol 1, no 3, Fall 1996.

Yeong E. Kim and Alexander L. Zubarev, "Gamow Factor Cancellation and Nuclear Physics Mechanisms for Anomalous Low-Energy Nuclear Reactions," *Journal of New Energy*, vol 1, no 3, Fall 1996.

* Hal Fox, Robert W. Bass, Shang-Xian Jin, "Plasma-Injected Transmutation," *Journal of New Energy*, vol 1, no 3, Fall 1996.
* Shang-Xian Jin & Hal Fox, "Characteristics of High-Density Charge Clusters: A Theoretical Model," *J. New Energy*, vol 1, no 4, p 5ff, Winter 1996, 16 refs, 2 figs.

Bockris and Minevski, "Two Zones of **Impurities** Observed After Prolonged Electrolysis of Deuterium on Palladium," *Infinite Energy*, vol 1, nos 5&6, 1996, pp 67-69.

Mizuno, Ohmori, Enyo, "Isotopic Changes of the Reaction Products Induced by Cathodic Electrolysis in Pd," *Journal of New Energy*, vol 1, no 3, Fall 1996.

Nuclear Wastes: Technologies for Separations and Transmutation, Committee on Separations Technology and Transmutation Systems, Board on Radioactive Waste Management, Commission on Geosciences, Environment, and Resources, National Research Council, published by National Academy Press, Washington, D.C. ©1996 by the National Academy of Sciences. [The essence of this large report is that there was no process known to the committee members that would be more economical than geologic storage of radioactive wastes. **Now there is.**]

FUSION facts

FORMERLY A MONTHLY NEWSLETTER FROM JULY 1989 TO DECEMBER 1996

WE DIDN'T QUIT, WE JUST CHANGED OUR LOCATION

FUSION FACTS to continue reporting on papers published in other venues

NEW DETECTION METHODS

Y. Arata, Y-C. Zhang (Welding Res. Inst., Osaka Univ.), "**Presence of Helium (^4He, ^3He) Confirmed in Highly Deuterated Pd-Black by the New Detecting Methodology**," *J. High Temp. Soc.*, vol 23 (1997), p 110. Also, *Cold Fusion Times*, vol 5, no 3, Fall 1997, p 8. (in Japanese, Engl. abstr)

This paper focuses in more detail on both the detection of ^3He and ^4He by the cycled mass spectroscopy technique of the authors, as well as their technique of varying the MS ionization voltage to help separate the masses (their "Vi effect"). Here they present many results that they believe confirm the finding of both ^3He and ^4He from deuterated Pd black in their double structured cathode.

HELIUM IN Pd-BLACK

Y. Arata, Y-C. Zhang (Welding Res. Inst., Osaka Univ.), **"Helium (^3He, ^4He) Within Deuterated Pd-Black,"** *Proc. Jap. Acad.* 73 B (1997) pp 1-6. Also, *Cold Fusion Times*, vol 5, no 3, Fall 1997, p 8.

A separate smaller paper, reporting the helium results only (see the large paper in *J. High Temp. Soc.* 1997 for all details.

Pd-BLACK ASSISTS TRITIUM PRODUCTION

Gilbert Bellanger(Comm. à l'Energie Atomique Ctr. d'Etudes de Valduc, Dept. Tritium, Is. sur Tille, France), Jean Jacques Rameau (Domains Univ., St. Martin d'Heres, France), "**Determination of Tritium Adsorption and Diffusion Parameters in a Palladium-Silver Alloy by Electrochemical Impedance Analysis**," *Fusion Techno.*, vol 32, no 1, Aug. 1997, pp 94-105, 12 refs, 14 figs, 4 tables.

The diffusion and adsorption parameter values of tritium in palladium-silver cathodic membranes used to produce pure tritium gas and its isotopes from highly concentrated tritiated water are determined. It is shown that permeation increases with applied cathodic potential, temperature, and the presence of a palladium black deposit on the cathodic entry surface. The diffusion coefficient, tritium concentration in the alloy, and the diffusion layer thickness depend on temperature. The presence of a palladium black deposit on the palladium-silver membrane improves the adsorption of tritium.

NO TRITIUM YIELDS

A. Bertin, M. Bruschi, V.M. Bystritsky, M. Capponi, S. De Castro, B. Cereda, A. Ferretti, T. Florkowski, D. Galli, B. Giacobbe, V.V. Gushchin, U. Marconi, I. Massa, C. Moroni, M. Piccinini, M. Poly, L.A. Rivkis, V.I. Sakharov, N. Semprini-Cesari, R. Spighi, V.A. Stolupin, V.N. Tebus, S. Vecchi, A. Vezzani, M. Villa, A. Vitale, J. Wozniak, G. Zavattini, A. Zoccoli, "**Absence of Tritium Yield in Metal-Deuterium Systems**," *Phys. At. Nucl.*, vol 59 (1996), p 934 (orig. *Yad. Fiz.* vol 59 (1996) p 976). Also, *Cold Fusion Times*, vol 5, no 3, Fall 1997, p 8.

This joint Italian/Russian/ Polish team continues to refine its search for nuclear effects in the Italian-style cold fusion experiments, loading deuterium as the gas, into Ti chips and cycling the temperature between liquid nitrogen and room temperatures. After a number of these cycles, the gas was driven off again by raising the temperature and the presence of tritium was checked for. For Ti, and some alloys such as Zr/Nb, La/Ni/Al etc, no tritium was found.

MUON-CATALYZED FUSION

Lali G. Chatterjee (Cumberland Univ., Lebanon, TN), Sunit K. Mandal (Jadavpur Univ., Phys. Dept., Calcutta, India), "**Can We Increase the Application Prospects of Muon-Catalyzed Fusion?**" *Fusion Technol.*, vol 32, no 2, Sept. 1997, pp 246-252, 14 refs, 3 figs, 7 tables.

Possibilities of improving the prospects of utilizing muon-catalyzed fusion are explored from several angles. Specifically, the use of photons to artificially enhance stripping by taking advantage of an enhanced stripping mechanism is suggested. On the muon production side, the use of heavy ions for the production of the parent pions is investigated.

LENR MODEL

Dan Chice, (Physics Dept., Univ. Lucian Blaga, Romania), "**Low Energy Nuclear Reactions**," *Elemental Energy ("Cold Fusion")*, no 22, pp 36-39

A very simple model involving a computer experiment to predict the energy distribution of a deuterium ion trapped in a metallic lattice is presented. The energy fluctuations are analyzed and the results are discussed in connection with the possibility of the low energy nuclear reactions in condensed matter occurring.

CONSTANT ENTROPY SYSTEMS

Remi Cornwall (Friends of John Gault, Forest Hill, London), "**Work in Constant Entropy Systems**," *Infinite Energy*, vol 3, nos 13-14, Mar-Jun 1997, pp 112-120, 14 refs, 8 figs.

This paper aims to show that heat is not a dead end of energy transformation and that macroscopic perpetual motion could be possible by the Maxwell Demon-like sorting process in constant entropy cycles and phase changes. A realistic device utilizing first order phase changes that could show this effect is then discussed. Heat re-use is the key to perpetual motion and this is shown possible by theorems developed herein that state: thermal particles of a working substance in a closed cycle can sort themselves at constant temperature by microscopic work (via theorem 1) and that macroscopic work can be liberated by a change of phase of the working substance (theorem 2). Key to development of the paper is the irrefutable *spontaneous temperature rise and density changes* on first order phase transitions which obey the 1st and 2nd Thermodynamic Laws, and again so when the phase changing catalyst is made and inserted into closed, isolated system.

The argument having proceeded along plausible lines (both theoretical and practical), then seeks to show that: if energy can leave the closed systems in question, then the Second Law is broken because there would be a spontaneous decrease in entropy by natural sorting processes. An interpretation of Entropy as merely the heat dissipated by dissipative (chemical and temperature gradient as opposed to conservative) potentials follows. The Principle of Potential Decrease is developed for the direction of 'Time's Arrow' which encapsulates the Second Law. This approach is linked in with chaotic dynamics of the three or more body problem and shows that time still has a direction, even at dynamic equilibrium; direction arises even though the underlying equations of motion are time invariant. The problem of the sense of time and memory is tackled, in a constant entropy system, with the said principle and the thermodynamic cycle discussed to show the 'one-wayedness' of influence (causality) and hence sense of time. The 'Teacup Paradox' is discussed and shows how that although, in principal, all the energy used to make the cup can be recouped once smashed by the thermodynamic cycle discussed, the *information* regarding the configuration of its atoms is always lost.

PLASMON STUDY

F. Frisone, "**Study of the Probability of Interaction Between the Plasmons of Metals and Deuterons**," *Nuovo Cimento*, 18D (1996), 1279. Also, *Cold Fusion Times*, vol 5, no 3, Fall 1997, p 8.

This evidently hastily written paper tries to build on from previous papers of Baldo et al (1990) and Rabinowitz (1990). It presents the results of some computations of a 1-E model of a metal lattice with deuterium as well as other (metallic) impurities, using the WKB approximation. The result is that the fusion probability increases by several tens of orders of magnitude, or the Coulomb barrier becomes much narrower, for an impure metal of the type Pt, Pd. or Ti, compared with the purer metal. This is not however spelled out in terms of actual probable dd fusion rates, so the bottom line is not clear.

INTERMOLECULAR BOND ENERGY

Peter Graneau (Ctr. Electromag. Res., NE Univ., Boston, MA), "**Extracting Intermolecular Bond Energy from Water**," *Infinite Energy*, nos 13-14, March-June 1997, pp 92-95, 13 refs, 4 figs.

When a small amount of energy from a high voltage capacitor is discharged through a few cubic centimeters of water, a strong explosion results which cannot be explained with thermodynamic nor electrodynamic forces. The 90-year history of unusual water arc explosions and their technological applications is reviewed. Three years ago it was discovered that what explodes is not the liquid water plasma but a quantity of dense cold fog generated in the plasma. The paper examines the science of this phenomenon.

It is concluded that tiny fog dr
molecular bond energy, per unit

energy difference is liberated
mechanically when the fog
repulsion forces between the fog
The extracted bond en
energy of the fog, was deposited in
in the clouds. It is argued that
he heat of condensation is transformed
that the explosions are actually
by concentrated solar energy
the atmosphere. The extraction
internal water energy does not
contribute to environmental

ZPF - INERTIA, GRAVITY, & MASS

Bernhard Haisch, Alfonso Rueda,
H.E. Puthoff, "**Physics Zero-Point Field: Implications Inertia, Gravitation and Mass** *Speculations and Technol* vol 20,1997, pp 99-114, 69 refs.

studies of the physics of
a classical electromagnetic
field (ZPF) have implicated
for a number of quantum

implies that the ZPF may play an
more significant role as the source
of matter. Furthermore, this

electromagnetism and inertia
that it may be fruitful to investigate
fundamental physical process of
c radiation by accelerated
could be interpreted as scattering

could also bear upon the origin of
reaction and on the existe
function underlying both thermal emission
dependent Davies-Unruh effect.

substantiated by further investiga
would be necessitated in physics.
overview of these concepts is presented
research agenda which could
lead to revolutionary
technologies.

aisch, Rueda, and Puthoff were
"Scientists of the Year" for their
paper on inertia ("Inertia as
Force, Phys. Rev. A, 49, 678-94).
NEN, February, 1994, pp 1-6.]

O.D. Kazachkovskii, "**A Mechanism for Cold Fusion** *At. Energy* vol 81 (1996), p 749; [*Atomn. Energ.* vol 81 *Atomn. Energ* vol 81, no 4 (1996), p 309]. Also, *Fusion Times* vol 5, no 3, Fall 1997, p 8.

K
paper of his on the discrete
of an electron filed in c
an explanation of cold fusion.
defects in PdD cause
potential energy peaks,

electrons there. This divides the
ice into cells, which can get excited
At certain cell dimensions, the dd
might take place. The model
current would favor fusion an a
should be used that has
a small lattice defect density.

INTERFACE

P.P. Khramtsov, O.G. **Peculiar Processes by Electrical Discharge throug Water-Vapor Interface** *Inzh.* ., vol 69, no 5 (1996), p [in Russian]; *Cold Times*,

In this experiment, the liquid
heavy water was also the cat
tungsten and hanging in the
head space. Voltages around
discharge current varied from 80 to
neutrons with a single detector
discriminator circuitry. The neutr
n/min. and a roughly linear
of neutron flux with cu
of around 1000 n/s at 100 mA.

TRAPPED NEUTRON COLD

H. Kozima, K. Khaki, T. Y Koike, " **Verification of the Trapped Neutron Model of Deuteron Fusion Systems** *Repts Fac. Sci. Shizuoka* ., vol 31 (1997), p *Cold Fusion Times* vol 5, no 3, Fall 1997, p 9.

has previously given his
explanation of cold fusion. He
that there are a lot of low-ener
from cosmic infall and reaction
hydrogen. These low-energy
deuterons in metal, so that we
reactions n + D →
gamma, and then the triton
further as t + d → ^{4}He
The gamma is absorbed quietly
and the high-energy neutron
other deuterons into more fusion.
authors examine this model
theoretically and semi-
and find that the model
observations.

HEAT, TRITIUM, & HELIUM

H. Kozima, S. Watanabe, K. Hiroe, M. Nomura, M. Ohta, **"Analysis of Cold Fusion Experiments Generating Excess Heat, Tritium and Helium,"** *J. Electrolanal. Chem.*, vol 425 (1997), p 173; *Cold Fusion Times*, vol 5, no 3, Fall 1997, p 9.

The results of Fleischmann et al (1989) and others are considered in the light of the authors' model of trapped neutron catalyzed fusion. They believe that surface layers of Li, laid down under electrolysis, as well as other chemical species, contribute to a number of nuclear reactions involving neutrons. Their model also suggests the possibility of a chain reaction, consistent with the melt-down claimed by Fleischmann et al (1989).

TNCF THEORY ANALYSIS

H. Kozima & K. Khaki (Shizuoka Univ., Japan), **"TNCF Analysis of Excess Heat in Ni/H/K System,"** *Elemental Energy ("Cold Fusion")*, no 22, pp 40-44, 20 refs.

The authors analyze the experimental results of experimental reports by Mills and Kneizys (a nickel, light water, potassium carbonate system) and also a similar system obtained from Hydrocatalysis Power Corp. (now BlackLight Power) with the experiment performed by Niedra, Myers, and Baldwin for NASA. In both cases the authors get essentially identical results by using their Trapped Neutron Catalyzed Fusion model. The conclusions are that cold fusion phenomenon occurs in a system not only with heavy water but also with light water and that acceptable cathodes are palladium, titanium, and nickel.

REDUCED RADIOACTIVITY

H. Kozima (Shizuoka Univ.), **"On the Reduced Radioactivity of Tritium Absorbed by Titanium,"** *Elemental Energy ("Cold Fusion")*, no 22, pp 45-48, 15 refs.

A remarkable experimental result of reduced radioactivity to tritium absorbed by titanium observed by O. Reifenschweiler is analyzed on TNCF model. The radioactivity measured is not discriminated in energy and is the total result of the beta from tritium and neutron in the sample. In TNCF model, trapped thermal neutron in a crystal can be affected by its decay behavior by the interaction with lattice nuclei. The reduction of the radioactivity is interpreted as a result of the neutron-lattice interaction, i.e. the disappearance of the radioactivity of some neutrons in the sample in an optimum condition. The density of the trapped thermal neutron contributing to the phenomenon observed was determined at approximately 10^{10} per cu. cm. in accordance with the previous data obtained in different experiments.

[The concept of the TNCF model is that there are trapped neutrons in many metal lattices and that the density of the trapped neutrons ranges from 10^5 to 10^{15} neutrons per cu. cm. If it is assumed that the atomic density in a metal lattice is about the same as Avagadro's number (about 6 x 10^{24} atoms per gram-molecular mole) then the ratio of atoms to thermal neutrons is in the range of 10^{18} to 10^8. Also, it appears that the standard half-life of a neutron in a vacuum of about 10.4 minutes must be considerably different for a thermal neutron imbedded in a metal lattice. Ed.]

HEAT IN PROTON CONDUCTORS

H. Kozima, Masayuki Ohta, Masahiro Nomura, & Kasuhiko Hiroe (Shizuoka Univ.), **"Analysis of Excess Heat Generation in a Proton Conductor,"** *Elemental Energy ("Cold Fusion")*, no 22, pp 49-53, 10 refs.

A careful observation of the excess heat generation in a proton conductor ... in D_2 gas ... was analyzed using the TNCF model. ... The data was analyzed on the assumption that the excess heat was generated by reactions of the trapped neutron with nuclei in the volume and in the surface layer ... The experimental results including the excess heat without D.C. power were explained consistently. The density of the trapped neutrons was determined ... [to be about] 4.0 x 10^{10} neutrons per cu. cm., which is in the middle of the values determined in other cold fusion materials.

DATA OF HEAT, X-RAYS, ^{4}He

H. Kozima, Katsuhiko Hiroe, Masabiro Nomura, & Masayuki Ohta (Shizuoka Univ.), **"Explanation of Experimental Data of X-ray, Heat Excess and ^{4}He in a PdD_x/Li System,"** *Elemental Energy ("Cold Fusion")*, no 22, pp 54-57, 12 refs.

Experimental data using the X-ray, the excess heat and ^{4}He in Pd_x/Li cathodes were analyzed using the TNCF model. A quantitative relation between the number of ^{4}He atoms and the amount of the excess heat generated in the cathodes were consistently explained using a single adjustable parameter n_n, density of the trapped thermal neutron, the value of which was determined as approximately 10^9 neutrons per cu. cm. A ratio of the number of the events N_Q generating the excess heat Q and the N_{He} were evaluated from the experimental data as 1 to 5 while the theoretical value was 1 using the model.

COLD FUSION PHYSICS

Hideo Kozima, Kaori Khaki, & Masayuki Ohta (Shizuoka Univ.), "**The Physics of the Cold Fusion Phenomenon**," *Elemental Energy ("Cold Fusion")*, no 22, pp 58-78, 52 refs.

More than 25 typical experimental data on the cold fusion phenomenon had been analyzed phenomenologically by the TNCF (Trapped Neutron Catalyzed Fusion) model based on an assumption of the quasi-stable existence of the thermal neutrons in solids with special characteristics, giving a consistent explanation of the whole data. The densities of the assumed thermal neutron in solids were determined in the analyses from various experimental data and were in a range of 10^3 to about 10^{12} neutrons per cu. cm. The success of the analyses verifies the validity of the assumption of the trapped thermal neutron. Physical basis of the model were speculated facilitating the quasi-stable existence of the thermal neutron in the crystals satisfying definite conditions.

[The real key to the assessment of the virtues of the TNCF model will be to check all of the many nuclear reactions that occur and determine if such nuclear reactions can be produced by neutrons and meet the requirements of the conservation rules for nuclear reactions.]

SPHEROMAK-LIKE FORMS

Alexander B. Kukushkin, Valentin A. Rantsev-Kartinov, Arkady R. Terentiev (Inst. Nucl. Fusion, Rus. Research Ctr., Kurchatov Inst., Moscow), "**Formation of a Spheromak-Like Magnetic Configuration by a Plasma Focus Self-Transformed Magnetic Field**," *Fusion Techno.*, vol 32, no 1, Aug. 1997, pp 83-92, 17 refs, 7 figs.

Experimental results are presented that verify the formerly predicted possibility of the formation of a closed, spheromak-like magnetic configuration (SLMC) by the natural magnetic field of a plasma focus discharge. The model is based on the self-generated transformation of a toroidal (i.e., azimuthal) magnetic field into a poloidal one. At the final stage of the discharge, the SLMC takes the form of a squeezed spheromak, which includes a combined Z-ϑ pinch as its major axis, **exhibiting a power density several orders of magnitude larger than that measured experimentally on a force-free flux-conserver-confined spheromak formed by helicity injection.** The results suggest the possibility of further concentrating the plasma power density by means of compressing the SLMC-trapped plasma by the residential magnetic field of the plasma focus discharge.

A qualitative model is given for the scenario of the SLMC-producing plasma focus discharge. Special emphasis is placed on the difference of this approach from conventional approaches to the role of magnetic field reconnection processes in plasma focus dynamics. The operational conditions necessary to stimulate SLMC formulation in high-current gaseous discharge systems and the used of SLMC-trapped plasmas are discussed briefly.

A SHORT REVIEW: A.B. KUKUSHIKIN'S PAPER

by Dr. X.S. Jin

The magnetic field in a plasma focus discharge could, in principle, be transformed to other types of configurations, for example, the spheromak-like configuration as the paper proposed. The main problem of this type of plasma device is that because of various macroscopic and microscopic plasma instabilities, the confinement time of the plasma could not be high (only ~ 10^{-6} s). Therefore, it can be used as radiation and/or neutron source, but there is no possibility to be developed to a (hot) fusion reactor.

This is not a device for charge-cluster formation:

1. What it confines is charge-neutral plasma, not charged particles.
2. The density of the plasma in the plasma focus discharge is about 10^{12} - 10^{14} particle / cm^3, not as high as ~10^{23} / cm^3, like in charge cluster.
3. It is for confinement of plasma, not for acceleration of charge clusters.

UNIFIED MATTER FIELD HYPOTHEOSIS

A.A. Nassikas (Larissa Ed. Inst. of Technology, Greece), "**The Hypothesis and the Equations of the Unified Matter Field**," *Infinite Energy*, nos 13-14, Mar.-Jun. 1997, pp 120-124, 17 refs, 1 fig. Originally published in Proc. Intnl. Conf. on New Ideas in Natural Sci., St.-Petersburg Phys. Soc., 1996.

The purpose of this paper is to state the equations of the unified matter field which is derived from the hypotheses that say spacetime can be regarded as matter. Thus the unification of the GRT (General Relativity Theory) and the QM (Quantum Mechanics) can be approx imated, the operators of spacetime magnitudes can be stated and the matter field can be described – in a Euclidean spacetime of reference – in its whole extent with spacetime wave functions. The charge space is regarded as an imaginary gravitational space which coexists with the real one, the two of them being interconnected. Thus a system of equations of space as a whole including the antimatter is stated and a possibility of application in gravitational technology is shown. A verification is given through the fractal geometry which seems to apply in many matter systems characterized by the property of selfsimilarity.

MEASURING CF REACTION

D. Li (Joshou Dazue Xuebao), "**Principle and Experimental Method for the Measurement of the Cold Fusion - Reaction Cross Section**," *Ziran Kexueban*, vol 17, no 3 (1996) p 65 (Chinese, Eng. abstr.); *Cold Fusion Times*, vol 5, no 3, Fall 1997, p 15.

"This paper discussed the measuring principle and the experimental method of the cold fusion-reaction cross section in detail, which provided a possible path for verifying the existence or no of the cold fusion. The principle and method discussed in this paper can be applied to some practical problems in electrochemistry." (Direct quote from the summary.)

GLOW DISCHARGE PROCESS

R. Lu, "**X-Ray Emission and Cold Nuclear Fusion in Glow Discharge Process of a Kind of Gas**," *Trends Nucl. Phys.*, vol 12, no 1 (1995), p 44 (in Chinese, Eng. abstr.); *Cold Fusion Times*, vol 5, no 3, Fall 1997, p 15.

This looks like a theoretical analysis of earlier results. The charge-dipole model was introduced to solve the Schroedinger equation and this results in the prediction of x-ray emission from such experiments. Cold fusion took place, says the abstract.

SrCe SOLID-STATE ELECTROLYTE

T. Mizuno, K. Inoda, T. Akimoto, K. Azumi, M. Kitaichi, K. Kurokawa, T. Ohmori, M. Enyo, "**Anomalous Gamma Peak Evolution from SrCe Solid State Electrolyte Charged in D_2 Gas**," *J. Hydrogen Energy*, vol 22 (1997), p 23; *Cold Fusion Times*, vol 5, no 3, Fall 1997, p 15.

A mixture of metal oxides of Sr, Ce, Y and Nb was mixed, sintered, powdered, washed with ethanol, formed into tablets and sintered again. A Pt layer was deposited on both flats, thin and porous enough to let hydrogen through. The tablets were then put into a chamber, evacuated and charged with D_2 gas. An ac voltage of 5-45 V and 0.0001 to 1 Hz was then applied (the "electrolysis") and gamma emission was measured by a Ge(Si) detector, before and after electrolysis. There were some gamma peaks observed with deuterium, but not without, or with hydrogen. These peaks indicated the formation of ^{197}Pt, ^{135}Sm and ^{155}Sm, by cold fusion of Pt with deuterium.

WATER ARC TRANSMUTATION

K. Nakamura, T. Kawase, I. Ogura, "**Possibility of Element Transmutation by Arcing Water**," *Kinki Daigaku Genshiuoku Kenkyusho Nenpo*, vol 33 (1996), p 25 (Japan., Eng. abstr.); *Cold Fusion Times*, vol 5 no 3, Fall 1997, p 15.

The abstract reveals that this was electrolysis in heavy water electrolyte (electrodes or electrolyte not given) with arcing. In the text we find "15V," a largish cell voltage. The head space gas was analyzed as a function of arcing time, and the abstract notes that carbon was converted to nitrogen. No visible explanation of where the carbon is from. Excess heat is said to have been found, by 21% over consumed power.

PARTICLE EMISSION SEARCH

J.P. Nicholson, "**A Search for Particle Emission from a Gas-Loaded Deuterium-Palladium System in the Alpha-Beta Phase**," *Fusion Technol.*, vol 30 (1996), p 383; *Cold Fusion Times*, vol 5 no 3, Fall 1997, p 15.

Pressurized D_2 gas was applied to Pd samples in a chamber containing a proton detector (s/c) and with a neutron detector (a single ^{3}He tube). In most runs, nothing was observed but there were two brief excursions above the background of the proton counter, corresponding to fusion rates of 4 x 10^{-21} fus/dd/s or so, or about Jones et al levels. The authors regard these results as inconclusive.

SPACE ENERGY FOR SPACEFLIGHT

Courtesy of the author

H.E. Puthoff, Ph.D. (Inst. Adv. Studies at Austin, TX), "**Can the Vacuum be Engineered for Spaceflight Applications? Overview of Theory and Experiments**." presented at NASA's Breakthrough Propulsion Physics Workshop on Aug. 12-14, 1997.

Quantum theory predicts, and experiments verify, that empty space (the vacuum) contains an enormous residual background energy known as zero-point energy (ZPE). Originally thought to be of significance only for such esoteric concerns as small perturbations to atomic emission processes, it is now known to play a role in large-scale phenomena of interest to technologists as well, such as the inhibition of spontaneous emission, the generation of short-range attractive forces (e.g., the Casimir force), and the possibility of accounting for sonoluminescence phenomena.

ZPE topics of interest for spaceflight applications range from fundamental issues (where does inertia come from, can it be controlled?), through laboratory attempts to extract useful energy from vacuum fluctuations (can the ZPE be "mined" for practical use?), to scientifically-grounded extrapolations concerning "engineering the vacuum" (is "warp-drive" space propulsion a scientific possibility?). Recent advances in research into the physics of the underlying ZPE indicate the possibility of potential application in all these areas of interest.

COLD FUSION THEORY

Hidetaka Sada (Mitsubishi Heavy Ind., Ltd., Nucl. Plant Engr. Dept., Kobe Shipyard, Japan), "**Theory of Nuclear Reactions in Solids**," *Fusion Technol.*, vol 32, no 1, Aug. 1997, pp 107-125, 32 refs.

A theory of cold fusion is presented, based on the Bloch theorem. The Bloch functions are used to represent the charged reactants and products of the nuclear fusion reaction in solid-state crystals. The nuclear fusion reaction is treated as a perturbation, the validity of which is shown. Field operator formalism, or quantum field theory, is used to calculate the transition matrix elements. Density of final states is calculated based on the phonon theory. The reaction rate and fusion power output density are calculated by Fermi's golden rule, and from them it is recognized that they look as if they had no reproducibility unless it is known that they depend on the number of the primitive cells in one crystal, the numbers of both the reactants and products, and the degree of the effectiveness of the Pauli exclusion principle. The triggering mechanism may also have a relation with its dependence on the aforementioned parameters.

Three selection rules are derived. One of them is very important and valuable because it suggests that cold fusion is a very clean energy resource; i.e., the radioactivity level of cold fusion is extremely low and safe compared with its output power or the current fission output power. The ratio (f/t) of the production rate of 4He (heat) to that of tritons is derived quantitatively and compared with the observed value. The necessary conditions for cold fusion to occur and continue are given. Quantitative descriptions about nuclear fusion reactions in light (or hydrogen) water electrolysis are also given.

NUCLEAR ASH & HEAT

Mitchell Swartz, "**Metachronous Release of Nuclear Ash Linked to Excess Heat**," *Cold Fusion Times*, vol 5, no 3, Fall 1997, p 1.

Helium-4 (^{4}He) is one product linked to the production of excess heat. This has been reported for palladium systems involving electrolysis (*Cold Fusion Times*, vol 2, no 1, vol 4, no 1) and ultrasound (*Cold Fusion Times*, vol 3, no 1). Drs. Yoshiaki Arata and Yue-Chang Zhang from Osaka University have identified both helium-4 and helium-3 as *do novo* nuclear products in deuterium heavy water cold fusion. Their careful work has involved quadrupole mass spectrometer (QMS) capable of clearly resolving any potentially generated ^{4}He [the putative deuterium nuclear reaction product ("ash")] from the highly deuterated palladium-black loaded metal (pd-black ~ 0.04 µM and arranged as atomic clusters).

CODEPOSITON OF Pd & D2

Mitchell R. Swartz (JET Energy Techno., Inc., Wellesley Hills, MA), "**Codepositon of Palladium and Deuterium**," *Fusion Technol.*, vol 32, no 1, Aug. 1997, pp 126-130, 14 refs, 2 figs, 1 table.

The quasi-one-dimensional model of isotope loading into a material relates the loading flux, the electrical order/thermal disorder ratio, and other physical issues. The theoretical nonequilibrium deuteron/palladium ratio at the surface of a palladium electrode, previously shown to depend on the loading flux ratio, is corrected both for intrapalladial diffusion of the loaded deuterons and for secondary changes in electrode volume, possibly explaining the often considerable time elapsed until the onset of the desired reactions.

IECEC CONFERENCE SELECTED ABSTRACTS:

The full papers from the 32nd IECEC "International Energy Technology" (Jul. 27 - Aug. 1, 1997, Honolulu, HI) are available from the American Institute of Chemical Engineers, GPO Box 29496, New York, NY 10087-9496, 1-800-242-4363. The Proceedings cost is $210.00.

Patrick G. Bailey (Inst. New Energy, Los Altos, CA), Hal Fox (Fusion Information Center, Salt Lake City, UT), **A Review of the Patterson Power Cell**," IECEC 1997 Proceedings, paper #97221.

An independent summary review is presented of the Patterson Power Cell™, as developed by Clean Energy Technologies. Information is drawn from publicly available information, and requested information and data from CETI. It is found that this cell seems to operate as advertized by CETI and that there is a very large amount of supportive documentation available in the public domain to support its operation and capabilities. The ability of such cells to neutralize alpha radiation is fairly well understood. An ability to neutralize gamma or other forms of radiation remains to be seen.

Patrick G. Bailey (Inst. New Energy, Los Altos, CA), Toby Grotz (Wireless Engineering, Craig, CO), James J. Hurtak (Academy for Future Science, Los Gatos, CA), **"Survey and Critical Review of Recent Innovative Energy Conversion Technologies**," IECEC 1997 Proceedings, paper #97215.

A summary review is presented of the experiments, motors, generators, devices, and demonstrations that have been reported in the past several years to produce near-unity or over-unity operation. The concepts of free-energy, zero-point energy, and over-unity devices are not new, and many examples of such devices have been built within the last 100 years. Several researchers are reviewed and a few are selected for immediate interest and support. Whether new forms of potential energy can be demonstrated and successfully utilized within the near future for the ultimate benefit of the human race remains to be seen.

Patrick G. Bailey (Inst. New Energy, Los Altos, CA), Nancy C. Worthington (AUM Foundation, Redwood City, CA), **"History and Applications of HAARP Technologies: The High Frequency Active Auroral Research Program,"** IECEC 1997 Proceedings, paper #97216.

A serious review of HAARP is presented. On the surface, HAARP appears to be a nice military "scientific endeavor aimed at studying the properties and behavior of the ionosphere." Upon further investigation, HAARP appears to be filled with secrecy and fraught with possible severe dangers. Attempts to reopen an official assessment of this program and its old out-dated unclassified Environmental Impact Statement have thus far failed. HAARP appears to be in use by ARCO to sell natural gas to the military that would otherwise be trapped in Alaska. The HAARP patents imply that Billions of Watts could easily be used to power HAARP, with no or few equipment upgrades. The patents are now owned by a major military contractor. Many of the possible applications, as stated in the actual patents supporting HAARP, would be classified. An Independent Review Committee needs to be formed to access the possible dangers of the various real and possibly classified HAARP projects. This Committee needs to be independent from US Federal politics, Alaska state politics, the US military, and ARCO oil interests, and would probably need to report to both the Congress and the Senate. There is a great need to form this Review Committee, and the time to form it is NOW!

Patrick G. Bailey (Inst. New Energy, Los Altos, CA), Toby Grotz (Wireless Engineering, Craig, CO), James J. Hurtak (Academy for Future Science, Los Gatos, CA), "**Review and Status of Reported Innovative Energy Conversion Technologies, Contrasted Using a Consistent R&D Ranking Scale**," IECEC 1997 Proceedings, paper #97212.

A summary review and status is presented of the experiments, motors, generators, devices, and demonstrations that have been reported in the past several years to produce near-unity or over unity operation. The concepts of free-energy, zero-point energy, and over-unity devices are not new, and many examples of such devices have been built within the last 100 years. Several devices are reviewed and ranked by a consistent research, development, and commercialization ranking scale. Those devices nearest to commercialization are identified and summarized. Whether new forms of potential energy can be demonstrated and successfully utilized within the near future for the ultimate benefit of the human race remains to be seen.

Giacomo Bisio (Energy & Conditioning Dept. Univ. Genoa, Italy), "**Thermodynamics of Magnetic Systems and Some Applications**," IECEC 1997 Proceedings, paper #97001.

Until quite recently, the theory of continuous media dealt mainly with diamagnetic and paramagnetic fluid. The researchers did not consider magnetizable fluids, probably because such media had not yet been discovered in natural conditions and did not exist until recently as manufactured products. However, in the early 1960s magnetic fluids (MF) could be synthetically prepared, since then technological interest in MF has grown rapidly.

Besides, magnetic refrigeration has been used for over 60 years as a technology to achieve temperatures below 1 K, employing magneto caloric effect of some solid material. However, in the last twenty years, the technology has been developing for refrigeration application above 1 K up to and including heat pumps above room temperature. The work has been multinational in scope and has focussed on the analysis of magnetic thermodynamic systems, investigation of magnetic material suitable for refrigerants, and development of prototype refrigerators.

After a synthetic review of the basic properties of MF, and of magnetic refrigerators and heat pumps, the aim of this paper is a thermodynamic examination of these systems in comparison with the relations usually applied to fluids. Three independent variables are generally considered, whereas usually only two variables have been considered till now for what is known to the author. Furthermore, some application of MF are taken into account; in particular, possibilities of converting thermal into mechanical energy are examined.

J. Dash, R. Kopecek, S. Miguet (Phys. Dept., Portland State Univ., OR), "**Excess Heat and Unexpected Elements from Aqueous Electrolysis with Titanium and Palladium Cathodes**," IECEC 1997 Proceedings, paper # 97368.

Presented here are results of research performed at Portland State University during the period 1994 to 1996.

Excess heat was produced at the rate of about 1.2 watts during electrolysis of heavy water with a titanium cathode weighing 0.0625g. Analysis of the electrodes before and after electrolysis with a scanning electron microscopy (SEM) and an energy dispersive spectrometer (EDS) revealed that new surface topographical features with concentrations of unexpected elements (V, Cr, Fe, Ni, and Zn) formed during electrolysis.

The morphology and micro composition of palladium after electrolysis in heavy water were studied. Fibers which appeared on the surface were observed to change with time. Evidence which supports the possibility of transmutation is presented.

Hal Fox (Fusion Information Center, Inc., Salt Lake City, UT), Patrick G. Bailey (Inst. New Energy, Los Altos, CA), "**Possible New Applications of Low-Energy Nuclear Reactions**," IECEC 1997 Proceedings, paper #97231.

Now that we understand the importance and nature of **cold fusion,** it is time to nominate B. Stanley Pons, Martin Fleischmann (Fellow of the Royal Society), and Kenneth R. Shoulders for a Nobel Prize. Pons and Fleischmann deserve the prize for their fundamental discovery of cold fusion. Kenneth R. Shoulders deserves a part of the prize for his excellent work in discovering and revealing how nuclear reactions take place in both the palladium-heavy-water system and in the sono-fusion system. A further degree of experimental information about nuclear reactions has been added by the Neal-Gleeson Process. A summary of these fundamental discoveries illustrates how important these discoveries have been and will be in the rapid advancement of the treatment of radioactive wastes (especially radioactive slurries); the production of thermal energy without neutrons; and probably the development of factory-made scarce elements.

Hal Fox (Fusion Information Center, Inc., Salt Lake City, UT), Patrick G. Bailey (Inst. New Energy, Los Altos, CA), "**High-Density Charge Clusters and Energy Conversion Results**," IECEC 1997 Proceedings, paper #97230.

Several recent developments of devices that produce low-energy nuclear reactions are explained by the deliberate or fortuitous production of high-density charge clusters. Some and perhaps most of the nuclear reactions in a variety of fluids and devices including the Pons-Fleischmann cold fusion discovery (palladium/heavy water systems), in nickel/light water systems, in Patterson Power Cells™, in low-pressure deuterium gas devices, in sparking-in-hydrogen devices, in exploding fire balls, and in the Neal-Gleeson Process are explained by the creation, launching, and impingement of high-density charge clusters on a target element or elements. This paper presents evidence of the application of the control and use of high-density charge clusters for **Plasma-Injected Low-Energy Nuclear Reactions** in the production of low-cost, nonpolluting, abundant thermal energy.

Peter A. Gibas, Friedrich Greilinger, Jean-M. Lehner, Werner Rusterholz (RQF Inst. Switzerland), "**Free Energy by Space Quanta Manipulation (RQM)**," IECEC 1997 Proceedings, paper #97145.

RQM - i.e. the Space (German: Raum) - Quanta - Manipulation stands for purposeful dilution resp. Compression of the space quanta medium and thereby resulting interactions with the matter contained within the influenced space volume.

RQM aggregates - containing a system of electromagnets set in a specific geometric arrangement - are capable of converting mechanical pressure differences within the space quanta medium (gravitational waves) into electric energy. The RQM technology was made possible as result of new scientific discoveries in the fields of electromagnetism, electrostatics, gravitation and magnetic flux dynamics as well as implosion techniques.

The RQM-effect (i.e. the pulsed emission of charge carriers from RQM base unit) has been achieved for the first time on June 2, 1995. At that time the perceived energy peaks similar to avalanche effects were reduced and brought under control. The experimental installation was then modified for battery operation and the proprietary newly developed electronic control was also integrated.

From there on it was possible to always accurately control the RQM installation.

The RQM Experimental Installation - shown and demonstrated in the laboratory near Rapperswil Switzerland - enabled at the end of September 1996 a stable energy yield with a factor of approx. 6 to 7.5 at 225 Watts. The efficiency is calculated by means of recharging the batteries. It is important to know, that for those tests and measuring works only the less efficient RQM sectors were activated because of security reasons.

We are now improving the efficiency and thus increase the useful energy by activating all RQM sectors. The problem of the excessive resonances while adding the more powerful RQM sectors is continually reduced. We expect that the efficiency as well as the yield of energy will increase exponentially.

The RQM tests and experiments are continuously monitored by high sensitivity measuring instruments. At no time any significant radiation fields and wave emissions have been detected, therefore, environmental compatibility is assured.

The achieved effects and the theoretical predictions - based on Crane's theory (causal physics) - led to a good number of relations with the established physical fundamentals. This refers particularly to results in the field of quantum electrodynamics as well as other areas of modern particle physics and findings concerning the structure of matter.

Michael G. Gilman (Lowe, Price, LeBlanc and Becker, Alexandria, VA), "**Licensing Patents and Technology by the Developer of the Technology**," IECEC 1997 Proceedings, paper #97190.

A patent and technology license is a complicated document requiring careful consideration by everyone involved. It especially requires a substantial input from the technologist-licensor. While Intellectual Property attorneys should always be employed to draft proper license agreements, their work product is only as good as the input that they receive from the person they represent, the technologist-licensor or the buyer-licensee.

Several areas of a license agreement should have great input from the technologist/licensor,such as: the technological field or fields of the license: the scope of the license: the exclusivity of the license and reversionary interests, if any: whether the license is limited to patent(s) or if it also includes know-how (technology): grant backs of further developments by the licensee in the field of the license: up front payments, running royalties and other forms of remuneration: right of first refusal for later developed technology and/or patents of the licensor; indemnification by the licensor in the event that the licensee is charged with infringement of other patents by practicing within the field of the license: and the licensor's obligations, if any, to enforce the licensed patents against infringing competition.

While the perspectives of the licensee and the licensor are clearly different, the same problems are addressed by both and the final agreement that is hammered out is the result of a meeting of the minds on all of these basic issues.

James J. Hurtak (AFFS Corp., Los Gatos, CA), Patrick G. Bailey (Inst. New Energy, Los Altos, CA), "**Cold Fusion Research: Models and Potential Benefits**," IECEC 1997 Proceedings, paper # 97163.

Observations have been made of deuteron-deuteron fusion at room temperature during low-voltage electrolytic infusion of deuterons into metallic titanium or palladium electrodes. Neutrons with an energy of approximately 2.45 MeV have been clearly detected with a sensitive neutron spectrometer at a rate of 2×10^{-3} n/s which cannot be accounted for by ambient-neutron background variations. The reaction has been known to yield excess (or "latent") heat, where D + D yields ^{4}He and 23.8 MeV. This paper will examine the latest experimental results from several international researchers and summarize several new theories of nuclear model interactions that have been put forth to explain these intriguing results.

James J. Hurtak, Ph.D. (AFFS Corp., Los Gatos, CA), Patrick G. Bailey, Ph.D. (Inst. New Energy, Los Altos, CA), "**RQM Technologies: Summary and Status**," IECEC Proceedings 1997, paper #97175.

An overview and critique is given of a new energy generation technology of Raum-Quantum-Manipulator (RQM, here referred to as Space Quanta Manipulation) currently under development by the Swiss Corporation Raum Quantem Motoren AG (RQM AG). RQM AG is testing several prototypes of a clean, noiseless, $C0_2$-free motor-generator as the beginning stage towards confirming the existence of Space Quanta Manipulation (RQM). On September 25, 1996, the RQM Experimental Installation was shown to demonstrate in their laboratory at Neuhaus, Switzerland for the first time a stable energy output factor greater than 100% at 225 Watts.

Ben Iverson (ITAM, Tigard OR), "**Foundations of Science, (Quantum Arithmetic)**," IECEC 1997 Proceedings, paper #97096.

Fibonacci, back in the foundations of our contemporary mathematics, was wrong, superficial, and incomplete. Euclid's Geometry gave us the proper terms 1500 years before that. The number groups, taken as Euclid stated, can represent a single frequency of energy. Using musical frequencies, we are able to check the integrated operation of various frequency combinations. Historically this has always been known as "Sacred Geometry", but there is nothing sacred about it. It is absolutely non-religious, but it is Divine. Presently it is known as the "Grand Unified Field". In my work it is called "Quantum Arithmetic". The search for new energy is useless and always will be non productive, without the truth and Law of Sacred Geometry.

Melvin H. Miles, Kendall B. Johnson (Chem. & Materials Branch, R. & Technol. Group Naval Air Warfare Center Weapons Div., China Lake, CA), M. Ashraf Imam (Physical Metallurgy Branch, Materials Sci. & Technol. Div. Naval Research Lab., Washington, DC), "**Anomalous Heat and Helium Production Using Palladium-Boron Alloys in Heavy Water**," IECEC 1997 Proceedings, paper #97538.

Reproducibility continues to be the major problem in the controversial cold fusion area. The best reproducibility for excess power was obtained using palladium-boron (Pd-B) alloy materials supplied by the Naval Research Laboratory (NRL), Washington, DC. Seven out of eight Pd-B cathodes produced excess power using D_2O-LiOD solutions. The collection and analysis of the electrolysis gases from one PdB experiment places the helium-4 production rate at 1.0 x 10^{11} ^{4}He/s•W. This is the correct magnitude, for typical deuteron fusion reactions that yield helium-4 as a product. Results of selected papers from the Sixth International Conference on Cold Fusion held October 13-18, 1996 in Hokkaido, Japan are summarized.

T. Mizuno, T. Akimoto, K. Kurokawa, M. Kitaichi, K. Inoda, K. Azumi, S. Simokawa (Dept. Nucl. Engr., Faculty of Engr., Hokkaido Univ., Sapporo, Japan), T. Ohmori (Catalysis Res. Center, Hokkaido Univ., Sapporo, Japan), M. Enyo (Hakodate Natl. Coll. Technol., Hakodate, Japan), "**Changes in Isotopic Distribution of the Elements on Palladium Cathode after Electrolyzed in D_2O Solution**," IECEC 1997 Proceedings, paper #97198.

Many elements on Pd electrodes were confirmed by several analytic methods; reaction products with the mass number up to 208 are deposited on palladium cathodes which were subjected to electrolysis in a heavy water solution at high pressure, temperature, and current density for prolonged time. These masses were composed of many elements ranging from hydrogen to lead. Extraordinary observations were the changes of their isotopic distributions in the produced elements; these were radically different from the natural ones. For example, natural chromium is 4.3% Cr50, 84% Cr52, 9.5% Cr53 and 2.4% Cr54. But the Chromium found on the Pd surface was 14% Cr50, 51% Cr52, 2.4% Cr 53 and 11% Cr54. Natural Isotopic distribution varies by less than 0.003% for Cr.

Essentially the same phenomenon was confirmed eight times with high reproducibility at high cathodic current density, above 0.2 A/cm[1]. All the possibilities of contamination had been carefully eliminated by several pretreatment for the sample and electrolysis system. It means that a nuclear reaction had taken place during the electrochemical treatment. It is indicating the role of new interactions discovered in the framework of a generalization of the usual quantum mechanics. Evidently such new interactions, due to the mutual overlap of wavepackets, should explain the new phenomenologies that are experimentally observed in this study.

T. Ohmori (Catalysis Res. Center, Hokkaido Univ., Sapporo, Japan), T. Mizuno (Fac. Engr., Hokkaido Univ., Sapporo, Japan), M. Enyo (Hakodate Natl. Coll. Technol., Hakodate, Japan), "**Nuclear Transmutation Induced by Light Water Electrolysis with Gold Electrode**," IECEC 1997 Proceedings, paper #97373.

Steady excess energy evolution ranging from 0.2 to 1 W, was observed during the electrolysis in neutral and alkaline solutions. At the same time, various unexpected elements, *eg.* Hg, Os, Kr, Ni, Fe, Si, Mg, etc, were found to be produced in the electrodes after the electrolysis. The amounts of Fe reached some 10 μ g after the electrolysis for 20-30 days. The isotopic distributions of above elements were evidently deviated from their natural isotopic abundance. For example, in some cases, the isotopic content of ^{57}Fe reached above 50 %, exceeding 20 times its natural isotopic abundance.

In addition, some 100 μ g of free porous precipitates were obtained when electrolyzed at a current density of > 0.2 A/cm^2. The major component was Au, however, several percents of Hg, Os, Fe, Si and Mg were contained.

The appearance of the electrode surface after the electrolysis was very anomalous on which a lot of volcano-like micro craters were found. The structure of the outside wall of the craters was porous, very alike to the structure of the precipitates. In the inside wall, there lied layers of fine hexagonal crystallites suggesting Au(111). This shows the occurrence of the recrystallization of Au substrate, suggesting an extraordinarily elevated heat evolution. These craters were distributed along the scraped edge of the electrode material artificially made or the rim of the micro holes and cracks, from which it is deduced that lattice defects concentrated on the edge or grain boundary of the electrode material would serve to induce the nuclear transmutation reaction.

David E. Reisner, T. Danny Xiao, Peter R. Strutt (US Nanocorp, Inc., North Haven. CT), Alvin J. Salkind (UMDNJ- Robert Wood Johnson Medical School, Bioengr. Div./Surgery Dept., Pscataway, NJ), "**Nanostructured Materials for Energy Storage and Energy Conversion Devices**," IECEC 1997 Proceedings, paper #97501.

US Nanocorp, Inc. (USN) has developed an aqueous solution reaction (ASR) technique scalable for high volume production of nanostructured materials (*n*-materials) for a wide range of applications. By definition, nanophase materials have at least one physical dimension less than 10 nanometers (nm) in length, an attribute which imparts exceptional properties to them because the particle dimensions are close to atomic dimensions and there are a very high fraction of atoms residing at nanocrystalline gain boundaries. The high surface area of these materials has significant implications with respect to energy storage devices with electrochemical active sites (batteries, ultra capacitors) and energy conversion devices depending on catalytic sites or defect structure (*e.g.*, fuel cells and thermoelectric devices).

Potential application areas in both energy conversion and energy storage are discussed. Morphological studies of manganese dioxide have revealed the existence of both nanoporosity and mesoporosity within unusual superstructures comprised of nanored building blocks. Nanophase n/ckel hydroxide has aim been synthesized. Preliminary electrochemical studies are reported.

Mitchell R. Swartz (JET Energy Technology, Inc., Wellesley Hills, MA), "**Biphasic Behavior in Thermal Electrolytic Generators Using Nickel Cathodes**," IECEC 1997 Proceedings, paper #97009.

Thermal spectroscopy, with attention to background noise, enables accurate determination of sample activity and has revealed a biphasic behavior to the generated excess heat. Nickel cathodes (using ohmic thermal and other metallic cathodic controls) were examined versus either platinum or gold anodes in light water systems. The peak power amplification [$_{OUT}$/ $_{IN}$ = $_{Ni}$] was in the range of ~2.27 (+/-1.02). Peak power outputs have been in excess of 2 watts, with power densities (nickel) of more than ~7 (+/-4.3) watts/cm^3. There may be several reasons for the biphasic effect. The origin of the site of the heat shifts at different locations within the π-notch.

Stanislaw J. Szpak, Pamela A. Mosier-Boss (NCCOSC RDT&E Div., San Diego, CA), "**Thermal and Nuclear Events Associated with Pd + D Codeposition**," IECEC 1997 Proceedings, paper #97120.

An alternate method for the initiation of thermal and nuclear events by electrochemical means is to employ electrodes prepared by the codeposition process. This process assures the formation of non-equilibrium electrode structures that promote localized potential, concentration, *etc.* gradients. Evidence for excess enthalpy, arising from randomly distributed discrete heat sources, is presented.

Their nuclear origin is supported by X-ray emission and tritium production. Emphasis is on experimental designs. We should like to suggest that *theory guides - experiment decides* is a preferable approach in this area of research.

Floyd A. Wyczalek (FW Lilly Inc., Bloomfield Hills, MI), "**Einstein's Special Relativity - Kinematical Part 1, Einstein for Philistines**," IECEC 1997 Proceedings, paper #97544.

I was motivated to read Albert Einstein's Special Theory of Relativity after viewing the NOVA presentation "Einstein Revealed." This presentation included several concepts such as: the *dilation of time,* the *contraction of space,* as functions of velocity; and, the mass of sunlight radiation striking the Earth surface. As examples, clocks run slower at the equator than clocks located at the Earth poles, an object traveling at 90% the speed of light contracts to 44% of its length as viewed by an observer at rest and at a right angle to the direction of motion of the object; and, about 4.5 pounds of sunlight per second impact Earth, energy mass equivalent *Einstein's* $E = mc^2$.

Prior to the NOVA presentation. I was only superficially aware of these concepts, but afterward resolved to obtain a copy of Einstein's 1905 paper published in the *Annafen der Physik 1905.* At my local public library. a synchronous event occurred in that the first book I selected from the many biographies on Einstein stored on the shelf was *Authur 1. Miller's ;1981 "Albert Einstein's Special Theory of Relativity"* and an appendix of Miller's translation German to English of Einstein's 1905 pamphlet of 24 pages.

Prior to reading Dr. Millers translation, I had assumed that Einstein's mathematics would be beyond my capability. Consequently, I was pleasantly surprised to realize that Einstein's paper presented the development of special relativity in very lucid and comprehensible terms.

The scope of the following summary of the bottom-line message, today's *so called news sound-byte,* of *Einstein's Special Relativity* is limited to the *Kinematical part 1* which deals with the *dilatation of time* or slowing down of moving clocks and the *contraction of length* of objects moving-in-space, relative to an observer at a resting reference point.

Lastly, Einstein's relativity is applied to illustrate current energy conversion engineering applications.

Floyd A. Wyczalek (FW Lilly Inc., Bloomfield Hills, MI), "**Einstein's Special and General Relativity Energy Conversion Engineering Applications**," IECEC 1997 Proceedings, paper #97552.

The mathematical concepts defined in Einstein's special and general relativity in 1905 and the years which followed, are routinely applied to many energy conversion engineering applications which are common today. Because of routine familiarity we have lost sight of the origin of the mathematical concepts. The mission of this paper is to review several applications and relate the mathematical concepts directly to Einstein's original 1905 and later papers. However, the scope of the following summary has been limited to highlighting the bottom-line equations involved in specific engineering applications.

JOURNAL OF NEW ENERGY

An International Journal of New Energy Systems Vol. 2, No. 2, 1997

Akimov - Torsion Field filter used to print solar photo.

Journal of JNE

Summer 1997
ISSN 1086-8259

Summer 1997 Vol. 2, No. 2

JOURNAL OF NEW ENERGY

An International Journal of New Energy Systems

The Journal of New Energy is published quarterly by Fusion Information Center, Inc., with offices at the University of Utah Research Park, Salt Lake City, Utah.

ISSN: 1086-8259

Mailing address:
Journal of New Energy
P.O. Box 58639
Salt Lake City, Utah 84158-0639
(801) 583-6232 FAX: (801) 583-2963

Printed in the U.S.A

Instructions to Authors:

Professional papers on cold fusion and other enhanced energy systems are solicited from scientists, engineers, inventors, and students. Papers from recognized professionals may be published immediately with an accompanying invitation for peer-review comments. Other papers will be submitted for peer review. Names and addresses of any reviewers will be sent to authors with reviewers' comments.

The Journal of New Energy (JNE) is devoted to publishing professional papers with experimental results that may not conform to the currently-accepted scientific models. The topics to be covered in this journal include cold nuclear fusion, low-energy nuclear reactions, high-density charge cluster technology (including some plasma circuits where enhanced energy is produced), high-efficiency motors or generators, solid-state circuits that appear to provide anomalous amounts of output energy, and other new-energy devices. Papers with experimental data are preferred over theoretical papers. Standard alternative energy topics such as hydrogen fuel, wind power, solar power, tidal power, and geothermal power are not solicited.

Authors should submit abstracts. If the abstracts are favorably considered for publication, the author will be sent an author's kit of instructions for the preparation of the paper. The editor and the editorial advisory board are responsible for making publication decisions.

Authors or their employers will be invoiced for production costs sufficient to cover the cost of publication in excess of subscription funds received. The JNE will try to match donors with authors from developing countries so that all acceptable manuscripts can be published. **Donors are requested to contact the JNE and they will be specially honored in the Journal.**

Editor Hal Fox is the leading founder of the Fusion Information Center which publishes both the *Journal of New Energy*, and *New Energy News*, a monthly newsletter covering new-energy developments for members of the Institute for New Energy. The previously published *Fusion Facts* newsletter (1989-1996) is now incorporated as a section in this Journal.