FUSION facts

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CONTENTS FOR JULY 1990

A. HAWAII U. AND TOKYO SCIENTISTS ACHIEVE NEW FUSION LEVELS

OVER 500 PERCENT EXCESS HEAT AT HAWAII

Professor Bruce Liebert, Mechanical Engineering Department of the University of Hawaii, has achieved over five times the amount of energy out compared to energy in (as briefly reported in the June 1990 issue of *Fusion Facts*). Dr. Liebert will be presenting a paper on his work at the forthcoming Cold Fusion session at the World Hydrogen Energy Conference #8. This conference is being held in Honolulu on Oahu in the State of Hawaii on July 23 through July 26, 1990. *Fusion Facts* will report further on this remarkable achievement in the August 1990 issue after Dr. Liebert presents his paper.

ONE MILLION NEUTRONS/SEC. IN TOKYO

Drs. Yamaguchi and Nishioka of the NTT Basic Research Laboratories, Musashino-shi, Tokyo 180, has made a remarkable experimental achievement by creating bursts of over one million neutrons per second from deuterated palladium. The replication of this experiment is strongly urged because it will certainly help to prove the existence of nuclear events in a palladium - deuterium system. The following is a review of this outstanding scientific development:

JAPAN - GIGANTIC NEUTRON BURSTS

Courtesy of Dr. Sam Faile and Dr. Takaaki Matsumoto

Eiichi Yamaguchi and Takashi Nishioka (NTT Basic Research Labs, Tokyo), "Cold Nuclear Fusion Induced by Controlled Out-Diffusion of Deuterons in Palladium", *Japanese Journal of Applied Physics*, Part 2 Letters, Vol. 29, No. 4, pages L666-L669, 26 refs.

ABSTRACT

A gigantic burst of (1-2) x 10^6 neutrons per sec has been detected from deuterated Pd plates with heterostructures set in a vacuum chamber. An explosive release of D_2 gas, biaxial bending of all the samples, and excess heat evolution were also observed at the same time. It has been concluded that these phenomena are caused by the cooperative production of deuterium accumulation layers at Pd surfaces due to controlled out-diffusion of D-atoms.

COMMENTS

The authors coat a l mm Pd:D (alpha phase) substrate with about 100nm of Au on one side and a thin coating (less than 10 nm) of Mn and O on the opposite side. The annealed Pd substrates are then immersed into D_2 gas

of 99.9% purity and a pressure of 0.5 atm. for 24 hours. The Au layer prevents outgassing of deuterium from the Pd and the Mn-O layer has a diffusion constant for D
that is less than the diffusion constant for Pd. Therefore, when the pressure on the substrate is reduced, the deuterium gas can accumulate in the interface layer (between the Pd and the Mn-O layer). The experimental results are (if the experiment is replicated properly) there is a burst of neutrons about three hours after reducing the pressure on the Pd substrate. In addition there is an explosive release of deuterium gas from the samples and also a biaxial bending of the substrate "due to uniform expansion of the surfaces with a thin Mn-O film". The authors also report that the stainless steel fixture used to support the substrate (3 or 4 substrates at a time) had increased in temperature by 50 deg C. It also appeared that the Au surface had been increased in temperature to above the alloying point (1064 deg C) as interpreted by the change in color of the Au plating.

Note: The importance of this experiment may lead many others to duplicate the results. The authors make the following comment: *"The difficulty in reproducing the present experiment may therefore be due to the fact that the cooperative production of D accumulation layers at Pd surfaces critically depends on the characteristics of the surface barriers."* Therefore, we urge that those who wish to replicate this outstanding experiment to communicate with the authors to obtain more details about the precise method used to prepare the Pd substrate. Ed

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B. FUSION NEWS FROM U.S.

PONS-FLEISCHMANN PAPER

Stanley Pons and Martin Fleischmann (U of Utah), "Calorimetric Measurements of The Palladium/Deuterium System: Fact and Fiction", *FUSION TECHNOLOGY*, Vol. 17, No. 4, July 1990, pages 669-679, 31 ref.

ABSTRACT

The technique, model, and experimental procedures as used in the Fleischmann-Pons calorimetric investigations are described.

DISCUSSION

It can be seen that most of the speculations that have been published about our experimental procedures and results are exaggerated at least. In particular, it is perfectly feasible to derive very accurate values of the heat output from the simple Dewar-type cells, provided adequate precautions are taken in the experiment design and modern methods of data analysis are used. We believe that more accurate values of the heat outputs could not be derived by using more complex instrumentation. A further consequence follows from the simplicity of the design. It is relatively straightforward and inexpensive to scale the cells so that the measured excess enthalpies become large compared to the random errors.

The marked excess enthalpies must be viewed in terms of the small negative excesses for the blank experiments. The increase in the excess enthalpy with current density is very marked and at least of the order I^2 with no indication of a limit at the highest current density used (1 A per sq cm). At this current density the excess enthalpy reaches 100 W per cu cm, in agreement with another recent report. The marked increase in the excess enthalpy with current density gives the results the appearance of a threshold phenomenon, but further measurements of very high accuracy at low current densities are needed to clarify this question. The scatter in the results at intermediate current densities is very large compared to the experimental errors, and this scatter may well be due to the approach to a threshold. The variability in this region may also explain some of the diversity in the reported results since such intermediate current densities have been extensively used by other investigators.

In addition to the baseline excess enthalpies, such as those given in Table 1 of the article, we have observed "Bursts" in the excess enthalpy production, which have now also been observed by a number of other research groups. The most prolonged burst that we have recorded to date is illustrated in Fig. 5a of the article. The excess specific enthalpy is given in Fig. 5b of the article, and the cumulative excess specific enthalpy in Fig. 5c of the article. It is not clear at the present time whether the baseline production of excess enthalpy and the bursts are in any way causally linked or whether the generation of excess enthalpy is linked to the production of tritium or neutrons. It is certainly true that the tritium levels increase markedly following a burst (factors of 8 have been observed in the National Cold Fusion Institute laboratories), but these increases are insignificant compared to the heat produced, if we assume the "normal" tritium output channel is responsible.

The rates of enthalpy production during the bursts are 17 times (plateau levels) and 40 times (peak values) of the total enthalpy input to the cells. The cumulative excess enthalpy for the bursts, shown in Figs. 5a, 5b. and 5c of this article, are approximately equal to 16 MJ per cu cm of Pd cathode (which far exceeds the heat that could be generated by any conceivable chemical process by a factor of 100 to 1000). This fact is equally true of the baseline excess enthalpies generated over the experimental durations (typically approximating 50 MJ per cu cm). We fail to see how such large specific enthalpies could be attributed to anything other than a nuclear process.
We note that the use of energy-efficient systems (D_2 ionization at the anode, small interelectrode gaps, high

electrolyte concentrations) would give energy-producing systems even for some of the baseline excess enthalpies already reported. During bursts, the system we have described is an effective energy producer even in its present inefficient form (oxygen evolution at the anode, relatively large anode-cathode spacing, low conductivity electrolyte).

COMMENTS

This paper should quiet the claims made against Pons and Fleischmann's work (due to suspected improper calorimetry). As an important observation of other's calorimetry work see the article by Noninski, "Observations of Excess Energy", *Fusion Facts*, Vol 1, No. 12, page 20, June 1990. Noninski's article suggests that proper evaluation of the calorimetry of N.S. Lewis, et al., *Nature*, Vol. 34, page 535ff (1989) shows that their data indicated excess heat in a cold fusion experiment. Ed.

Note: One of the long-awaited papers from Pons and Fleischmann is the following: M. Fleischmann, S. Pons, M. Anderson, L.J. Li, and M. Hawkins, "Calorimetry of the Palladium-Deuterium-Heavy Water System," *Journal of Electroanalytical Chemistry*, (in press). We will review the article as soon as it is published. Ed.

NRL - BLOCH-SYMMETRIC FUSION

Talbot A Chubb (Bendix Field Engineering Corporation, MD) and Scott R. Chubb (Naval Research Laboratory, Wash.D.C.), "Bloch-Symmetric Fusion in PdD_x", *FUSION TECHNOLOGY*, VOL. 17, No. 4, July 1990, pages 710-712, 5 ref.

ABSTRACT

A theory of solid-state fusion based on the formation of D^+ Bose Bloch condensate (BBC) is summarized. The first step toward fusion is a coalescence reaction that converts a multiple-occupation state of chemical density into a state of nuclear density. In PdD_x, conditions for formation of BBC are favorable when x is near unity, due to avoidance of lattice strain energy that otherwise contributes to the chemical potential. Fusion obeys a "boson in, boson out" selection rule and avoids the proton and neutron fluxes of collision-induced fusion. Some cold fusion studies are compatible with the theory and indicate the possibility of largely radiation-free commercial nuclear power from an inexhaustible fuel supply.

COMMENTS

Please note that this issue includes an article from Dr. Talbot Chubb with a more tutorial discussion of his theory. See Section D.

COLD FUSION CONUNDRUM at TEXAS A&M

Courtesy Dr. Samuel Faile

Gary Taubes (a science writer), "Cold Fusion Conundrum at Texas A&M", *Science*, Vol 24 8, No. 4961, June 15, 1990, page 1299-1304, no references.

Robert Pool, "Wolf: My Tritium Was An Impurity", a partial-page insert in the above article on page 1301.

COMMENTS

The *Science* article by Gary Taubes is essentially an allegation that Texas A&M is allowing scientific fraud to be performed on campus. The article provides considerable innuendo and veiled accusations, and in the opinion of this editor, is unworthy of publication by the American Association for the Advancement of Science. See the report from Marjorie Hecht in Section D, Short Articles from Authors.

The inset by Pool contains the following: "And since several other labs that saw tritium in fusion cells got their palladium from the same supplier as Wolf (Hoover and Strong, Inc. from Richmond, VA). The contamination that Wolf found throws added doubt on much of the tritium data reported in this country."

Fusion Facts called Torry Hoover of Hoover and Strong and obtained the following information. Hoover and Strong buy, refine, and market Pd and Pt to the jewelry trade. Mr. Hoover stated that they get their Pd and Pt from the same sources, in general, that their competitors obtain Pd and Pt. The only difference would be in their individual proprietary processes of refining the metals. The product created for the jewelry trade is brought to a 99.95% purity and the processors are not concerned with nor do they test for tritium or for many other materials that may constitute a part of the 0.05% of impurities.

Mr. Hoover stated that all of their Pd is taken through a molten process. In part of their refining, the Pd is treated electrochemically. In answer to a speculative question about producing tritium electrochemically, Mr. Hoover stated that he did not know but that it might be conceivable. No one has shared with Mr. Hoover, the precise amount of tritium that was found in the Pd samples. Ed.

Note: Because of this high temperature treatment and the fact that hydrogen has a high rate of diffusion at temperatures above 200 degrees, it is difficult to understand why any tritium should remain in the Pd. We suggested to Mr. Hoover that he might want to test for tritium in the electrolyte phase and then offer tritium-free or low-tritium Pd to the scientific community. Ed.

COMMENTS

In a personal communication with Nigel Packham (TAM) we learned the following: If a pocket of tritium were contained within a palladium rod used as a cathode in an electrochemical fusion cell, the probability that such a tritium atom would leave the rod and enter the electrolyte is 10^{-24}. Ed.

COLD FUSION SAGA
Courtesy of Dr. Samuel Faile

I. Amato, "Cold Fusion Saga: Trials and Tribulations", *Science News*, June 16, 1990, Vol. 137, No. 24, page 374.

Amoto reports on Kevin L. Wolf's finding of tritium in several unused segments of Pd wire obtained from Hoover & Strong, Inc. of Richmond, Va. Article states, "Some scientists insist palladium contamination does not explain all the tritium observations made to date. For Example, Edmund K. Storms of the Los Alamos National Laboratory told *Science News* that only one of his 11 tritium-positive experiments involved palladium from Hoover and Strong. `We don't think our wire has been contaminated,' he says."

The article also reports on the planned science audit that is planned for the National Cold Fusion Institute and the controversy concerning the publications of an article in *Nature* by U/U physicist Michael J. Solomon on radiation detection in Pons and Fleischmann's lab. Ed.

TRITIUM AT TAM

Staff, "Science Journal Questions Texas A & M Experiments", WSJ, June 15, 1990, page B4.

News Roundup article cites the article by Gary Taubes which appears in *Science*, June 15, 1990. Taubes charges that Texas A&M researchers failed to protect experiments from possible fraudulent contamination so that results are questioned. Taubes offers no specific evidence. John Fackler, dean of the college of science is quoted as saying, "this kind of journalism isn't appropriate to a journal like *Science*".

TRITIUM AT LOS ALAMOS

Edmund Storms and Carol Talcott (Los Alamos National Laboratory New Mexico), "Electrolytic Tritium Production", *FUSION TECHNOLOGY*, VOL. 17, No. 4, July 1990, pages 680-695, 15 ref.

ABSTRACT

Fifty-three electrolytic cells of various configurations and electrode compositions were examined for tritium production. Significant tritium was found in 12 cells at levels between 1.5 and 80 times the starting concentration after enrichment corrections are made.

CONCLUSIONS

Tritium was produced in 11 cells at levels between 1.5 and 80 times the starting concentration. Over 1500 tritium measurements were made on 53 cells of various designs. As can be seen in Table VIII of the article, the total uncertainty in tritium content for these measurements is plus or minus 14 dis/min per ml, which is 0.1 times the starting concentration. Thus, the proposed tritium excess is well outside the uncertainty in the total measurement.

Fourteen inactive cells are described in the work and are used as reference standards. In addition, a cell containing normal water (0.2 N LiOH) has been studied recently and shows no tritium increase after 30 days. The effects of chemiluminescence, counting efficiency, and sampling error have been studied but are not described in this technical note. Based on this background, we believe that the tritium is real; it is not caused by contamination, and it is not a product of normal electrolysis.

The distribution ratio (gas/liquid) for tritium in the electrolyte is not a constant but appears to be influenced by the cell current density and, perhaps, by the cathode surface characteristics. This work produced gas/liquid ratios between 0.82 and 1.1.

Tritium production is found to occur after times as short as 2 days after electrolysis is started and with cathodes having an average D/Pd ratio as low as 0.70. Only 1 cell in 10 is found to be active.

UNIVERSITY OF ARIZONA

R. H. Parmenter and Willis E. Lamb, Jr., (Dept. of Physics, Arizona Research Laboratories, U of Arizona), "More Cold Fusion In Metals: Corrected Calculations and Other Considerations", *Proceedings of the National Academy of Sciences of the USA*, vol. 87, pages 3177-3179, April 1990, 10 ref.

ABSTRACT

A simple model of a metal containing deuterons is considered. The example of palladium is treated in detail. In contrast to a previous calculation, it is shown that the

effect of screening of Coulomb fields by conduction electrons is sufficient to allow a deuteron pair to fuse at a rate of 10^{-18} sec-1; five powers of 10 larger than some experimental results. It is shown that the Oppenheimer-Phillips process enhances the rate by a factor of 1.77. Difficulties with applying the model to titanium are discussed.

COMMENTS

The authors note that this paper corrects calculations given in their previous paper (Parmenter & Lamb, *Proceedings of the National Academy of Sciences*, *USA*, Vol 86, 1989, pages 8614-8617. These later results indicate possibility of deuterons in interstitial traps fusing at a rate that is 5 powers of 10 larger than that observed by Jones et al. The previous model and article cited results that were about 7 powers of 10 smaller than seen by Jones et al. Ed.

NRL - THIN FILM Pd FUSION

G. P. Chambers, J. M. Eridon, and K. S. Grabowski (Surface Modification Branch, Naval Research Laboratory, Wash. D. C. 20375-5000), "Upper Limit On Cold Fusion In Thin Palladium Films",*PHYSICS REVIEW B: CONDENSED MATTER*, Vol. 41, No. 8, 1990, pages 5388-91.

ABSTRACT

Thin Pd films were bombarded with low-energy(1.5-keV) D at high current densities (0.11 mA per sq cm) and at 40-330 K in an effort to produce fusion at low temps. The film was monitored with a surface barrier detector to detect possible reaction products. No evidence was found to support the hypothesis that the heat-producing reactions within D-charged Pd are nuclear in nature.

U. OF MINNESOTA - FUSION RATES

J. W. Halley and J. L. Valles (School of Physical Astronomy, U of Minnesota), "Estimate Of Nuclear Fusion Rates Arising From A Molecular-Dynamics Model of Palladium Deuteride" *PHYSICAL REVIEW B: CONDENSED MATTER*, 1990, Vol. 41, No. 9, pages 6072-5.

ABSTRACT

An estimate is described of the fusion rate of D in Pdmetal based on molecular dynamics simulation. Quantum effects on the motion of the D were treated semiclassically, and the effects of electronic screening of the interactions were studied by varying a screening parameter in the potentials. Low fusion rates were found

of the order of 10^{-150} s^{-1} per d, consistent with bounds suggested by A. J. Legbett and G.Baym (1989).

BROOKHAVEN - CALORIMETRY ERRORS

Kenneth A. Ritley, Peter M. Dull, Marc H. Weber, Michael Carroll, James J. Hurst, and Kelvin G. Lynn (Brookhaven National Laboratory), "The Behavior of Electrochemical Cell Resistance: A Possible Application to Cold Fusion Experiments", *FUSION TECHNOLOGY*, VOL. 17, No. 3, July, 1990, pages 699-703, 8 ref.

ABSTRACT

Knowledge of the basic electrochemical behavior found in typical cold fusion experiments is important to understanding and preventing experimental errors. For a Pd/LiOH(D)/Pt electrochemical cell, the applied cell voltage/current relationship (the effective cell resistance) does not obey Ohm's law directly; but instead exhibits a complicated response to the current, voltage, temperature, electrolyte conductance and other factors. Failure to properly consider this response can possibly result in errors that could affect the heat balance in calorimentry and temperature measurement experiments. Measurements of this response under varying voltage, temperature, and electrolyte conductivity conditions are reported. A plausible scenario in which the temperature dependence of the effective cell resistance can either exaggerate or ameliorate novel exothermic processes is suggested.

SUMMARY

Measurements have been described involving electrolysis cells that are typical of those used in cold fusion experiments. It was shown that, although the conductance of the electrolyte responds to temperature as expected, the effective cell's resistance depends on temperature, voltage, current, electrolyte conductance, and possibly the cathodic deuterium concentration and surface conditions A possible scenario was suggested in which a power supply could cause a spontaneous "heat burst" that might be interpreted as a anomalous heat event not associated with a known chemical proces. The possibility of a novel exothermic or cold nuclear fusion process occurring at room temperatures in electrolytic systems must be exhaustively studied in order to place strict limits on identifiable nuclear or chemical processes that can occur. This technical note has identified several possible sources of error in such experiments.

COMMENTS

The authors are pointing out possible errors that could account for cold fusion not producing excess heat. It is suggested that they also communicate with Dr. James

Breem at Brookhaven who has produced both excess heat and tritium. Ed.

HYDROGEN ABSORPTION - ALLIED CHEMICAL

Arnold J. Maseland (Materials Research Center, Allied Chemical Corporation, New Jersey), "Hydrogen Absorption In Crystalline And Non-Crystalline TiCu", paper available through company at Morristown, N.J. 07960.

ABSTRACT

Body-centered tetragonal gamma-phase TiCu absorbs hydrogen below about 200 degrees C to form an intermetallic hydride of composition near TiCuH.
The metallic glass phase of the same composition TiCu, also absorbs hydrogen to approximately the same composition without crystallization taking place. The thermal behavior of both the crystalline and glassy hydride phases have been studied. The results of this study are discussed and a comparison between the behavior of the two materials will be made.

HYDROGEN SOLVENTS - U. PITTSBURGH

W. E. Wallace, A. Goudy, R. S. Craig, D. M. Gualtieri and T. Takeshita (Dept. Chemistry, U of Pittsburgh), "Intermetallic Compounds as Solvents For Hydrogen", paper available from author at Pittsburgh, PA 15260.

ABSTRACT

$LaNi_5$ and many other intermetallics, particularly those containing rare earth elements, absorb hydrogen copiously. The proton density in many of these materials exceeds that of liquid hydrogen; thus these materials are of significance for hydrogen storage. The most remarkable feature of intermetallics containing rare earths is not their capacity for hydrogen, but is instead the rapidity with which they absorb and release hydrogen. This indicates truly remarkable surface characteristics since molecular hydrogen must be dissociated at the surface prior to entering the lattice. Earlier work on RNi_5 and RCo_5 systems (R is a rare earth element) by Dutch workers has now been extended to RCo_3, R_2Co_7 and RFe_3 binary systems and to $ErFe_{2-z}$ M_x (M=Al, Mn and Co) and $ErCo_{2-x}$ Ni_x ternaries. The hydrogen concentration in $ErFe_{0.8}$ $MN_{1.2}$ $H_{4.6}$ is about 7 X 10^{22} atoms/cm^3, which appears to be the highest concentration achieved to date in intermetallics involving a rare earth and a 3d transition metal. Thermodynamic and kinetic features of these systems are reviewed.

LIVERMORE NATIONAL LAB - AMORPHOUS Ti-Pd

A. F. Jankowski, M.A. Wall and P. E. A. Turchi (Lawrence Livermore National Laboratory, Calif.), "Crystallization of Amorphous Ti-Pd", *Journal of the Less-Common Metals*, vol. 161, No. 1, June 1990, pages 225-124, 17 ref.

ABSTRACT

Phase information in the Ti-Pd alloy system is investigated by using a physical vapor deposition technique. An amorphous phase at 65 at.% Ti has been produced. Upon heating this thin film amorphous structure, a direct transformation to a high temperature b.c.c. phase results, followed by ordering and phase separation. The details of the amorphous structure and transformation are analyzed using X-ray diffraction, hotstage transmission electron microscopy, Auger electron spectroscopy and differential scanning calorimetry.

SUMMARY

The measured composition of the as-deposited Ti-Pd thin film (around 35 at.%) has initially precluded our intended formation of a b.c.c. phase above the A15-ordered structure. The palladium composition was too high (greater than 33 at.% for this purpose. Nonetheless, several interesting features of the Ti-Pd thin film alloy have been disclosed. An amorphous structure has been uniquely identified in the as-deposited film. The amorphous-to-crystalline transformation is first order for those samples conventionally prepared in plan-section. The DSC (Differential Scanning Calorimetry) results obtained confirm the amorphous-to-crystalline transformation of the as-deposited Ti-Pd structure as seen in the TEM (Transmission Electron Microscopy). The nature of the transformation was similar to most glassy metals. In this particular case, primary crystallization to an apparent elevated temperature cubic phase (Beta-TiPd) was followed by subsequent ordering. Phase separation then occurred with the distinct presence of both Beta-TiPd and Ti_2 Pd, consistent with the known phase field region. The temperatures measured using the TEM hot-stage paralleled events resolvable using DSC. The TEM event temperatures are apparently, however, at temperatures 25-30 degrees C above the DSC events. The absolute accuracy of the TEM hot stage temperatures may be in question.

The use of thin film deposition processes should prove useful to study the short range ordering of the b.c.c. solid solution above an A15 structure, if it exists. This appears promising as crystallization of the amorphous $Ti_{0.65}$ - $Pd_{0.35}$ alloy proceeded directly to the elevated temperature, cubic phase. Alloys with a lower palladium composition will be prepared for this purpose.

NOTE: This article may be of some importance as reference material inasmuch as fusion successes have been achieved with both Ti and Pd. Ed.

BOOK: EVERYTHING KNOWN SO FAR

Rix Dobbs, *Cold Fusion, Everything Known So Far.* June 1990, 55 pages, 45 ref., published by the author, 4375 Old Williamsburg Road, Sandston, Va. 23150.

COMMENTS

Rix Dobbs has written a brief review of cold fusion and has included some comments (from an article in *Fusion Facts*, by permission) on the problems of making a successful cold fusion experiment. The booklet is written for the intelligent layman and not for scientists. His booklet has been advertised in a popular science magazine at a price of $8.85.

Dobbs booklet includes an article by Harold Hough entitled, "Cold Fusion, Government, and Freedom", which predicts that the government will attempt to hamstring the development of cold fusion. The booklet also includes a list of fifty scientists who are working on cold fusion. The tenor of the book is positive but, of course, lacks proof of the reality of cold fusion.

LETTERS FROM READERS

NEW EXPERIMENTS AT TATA

Ramtanu Maitra (the Editor of *Fusion Asia*) writes from New Delhi, India, that he will be getting more information to share with *Fusion Facts*. He reports that Dr. Santhanam at TIFR (Tata Institute for Fusion Research) has begun a new set of experiments. Will report more later.

SINGLE CRYSTAL PALLADIUM

Dear Editor:

Not long ago I read the report prepared by the Scientific Panel of the Energy Research Advisory board to the U.S. Department of Energy on Cold Fusion.

During my research on cold fusion I have arrived at the conclusion that quite a lot of enigmatic results presented in the DoE report may be explained if one assumes that in the original experiment the Pd electrode was made from monocrystalic palladium.

Before the detailed paper on the problem is published in standard Journals it seems worth while to inform the workers in the field about the main results of this research. The newsletter, *Fusion Facts,* seems to be a proper place for printing a rapid communication on the problem - I suppose the enclosed note is sufficiently short and worthy of publication.

Sincerely Yours,

M. Gryzinski (POLAND)

See section D. for Professor Gryzinski's short article.

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C. FUSION NEWS FROM ABROAD
FRANCE - LIMITS ON FUSION

R. Aleksan , M. Avenier, G. Bagieu, J. Bouchez, J. F. Cavaignac, J. Collot, M. C. Cousinou, Y. Declais, and Y. Dufour (Dept. Phys. Part. Elem., CEN-Saclay, F-91191 Gif-sur-Yvette, Fr.), "Limits On Electrochemically Induced Fusion Of Deuterium By Neutron Flux Measurements", *PHYSICS LETTER B*, 1990, Vol. 234, No.3, pages 389-94.

ABSTRACT

Limits on the n flux produced by electrochemically induced nuclear fusion reactions were set using an efficient and low background detector based on ^{6}Li doped liquid scintillator to detect the 2.45 MeV n. These limits are of the order of 50 n/h for different electrolysis experimental conditions and are greater than or equal to 30 times lower than the claimed positive results of M. Fleischmann et al. (1989) and S. E. Jones et al. (1989).

ITALY - CALORIMETRY

Mohamed Abdel Harith, Vincenzo Palleschi, Azenio Salvetti, Giuseppe Salvetti, Dharm Pal Singh, and Moreno Vaselli (Instituto di Fisicas Astomica e Molecolare del C.N.R., Italy), "Theoretical And Experimental Studies On The Cold Nuclear Fusion Phenomena", *FUSION TECHNOLOGY*, vol. 17, No. 4, July 1990, pages 704-709, 16 Ref.

ABSTRACT

A realistic estimate of the interionic potential that may account for the experimentally observed fusion rates (approximately 10^{-23} deuterium-deuterium fusions per sec). in palladium is presented. Moreover, some preliminary calorimetric studies on the hydrogen absorption process in

palladium, performed in a cell with pressure up to 20 bars are discussed. A detailed analysis of the sensitivity and calibration of the calorimetric system is also presented.

CONCLUSIONS

In this technical note, we have shown that efficient screening of the deuterium ion potential, due to the surrounding electrons, and a strong D-D short-range correlation, occurs in metals at low temperatures. Both these effects lead to a large enhancement of the nuclear fusion rate compared to the predictions of the classical theoretical approach, yielding a fusion rate of the same order as that observed in recent experiments. We have also presented some preliminary experimental results and the analysis procedure used to extract calorimetric information about the absorption of hydrogen in palladium. The extreme sensitivity of our experimental
system is clearly encouraging for forthcoming calorimetric studies of the cold nuclear fusion phenomenon.

COMMENTS

The authors point out that a previous calculation (Leggett andBaum) of upper bounds for nuclear fusion rates is based on the assumption, "the helium atom affinity in palladium or titanium, is independent of the deuterium concentration in the metal." The authors suggest that may not be the case. Ed.

ITALY - GRAN SASSO LABS

Francesco Celani and Antonio Spallone (Instituto Nazionale di Fisica Nucleare, Italy), Sandro Pace and Basilio Polichetti (U of Salerno, Italy), Aniello Saggese and Lorella Liberatori (Consorzio Interuniversitario Nazionale Fisica della Materia, U of Salerno, Italy), Vittorio Di Stefano and Paolo Marini (ILVA-Centro Sculuppo Materiali, Italy), "Further Measurements On Electrolytic Cold Fusuion With D_2O and Palladium At Gran Sasso Laboratory", *FUSION TECHNOLOGY*, vol. 17, No. 4, July 1990, pages 718-724, 4 ref.

CONCLUSIONS

Various tests in electrolysis with LiOH-D_2O and palladium cathodes were carried out. Some showed neutron production above the background. Careful tritium analysis performed in electrolytes and in recombined D_2O showed a tritium production that could not be explained by electrolytical enrichment only. Assuming that tritium and neutrons were obtained in the same tests, the tritium-to-neutron ratio should range between 5 X 10^5 and 10^7.

ABSTRACT

Several experiments were performed at the Gran Sasso Laboratory on a 0.8-cm-diam X 5-cm-long, hyperpure, high-temperature vacuum-annealed palladium rod used as a cathode for electrolytic infusion of D_2O and 0.1 M LiOH with regular additions of gaseous CO_2 at a current density of 60 mA/cm^2. In the very low background radiation environment, several gamma bursts lasting up to 15 min were detected whose intensity, in terms of cold fusion, was >10^{-20} fusion/(deuteron pair per s). Under normal background conditions, none of these burst signals would have been detected with statistical significance. The shape and intensity of these signals are quite similar to those detected previously.

CONCLUSIONS

Except for the anomalous shot event, we did not detect any large neutron counts during the bursts. If we assume nuclear fusion and a branching ratio of 50% between the two fusion production channels (t + p and ^{3}He + n), given the above estimated fusion rate, we would expect a large neutron emission to be detected by the neutron counters. Therefore, if we assume d + d fusion, we have to assume a neutronless process.

Fracto-emission phenomena can result in detection of very intense emission of charged and neutral particles, as widely reported in the literature. The intense low-energy (1- to 100-keV) gamma can easily simulate signals of enough energy to overlap the 800-keV threshold of our large NaI(TI) detector.

Thus, it is not yet clear whether all or a fraction of the detected signals arise from nuclear fusion reactions. We plan a new experimental setup with a gamma detector and associated electronics for pulse-height analysis that will be able to follow signals of very intense bursts, but with a very low repetition rate.

COMMENTS

One of the interesting additions to the electrochemical experiments is the regular additions of gaseous carbon dioxide to the electrolyte. A constant current density of about 60 mA per sq cm was interrupted by some power outages. However seven bursts of gamma rays were detected by the NaI(Ti) detector ranging from total excess counts of 57 to 7,250 counts. Ed.

ITALY - CISE

Pier G. Sona, Fulvio Parmigiani, Franco Barberis, Adriano Battaglia, Renza Berti, Giovanni Buzzanca, Aldo Capelli, Davide Capra, and, Marco Ferrari (CISE SpA, Via Reggio Emilia 39, Segrate Milano, Italy, "Preliminary Tests On

Tritium And Neutrons In Cold Nuclear Fusion Within Palladium Cathodes", *Fusion Technology*, Vol. 17, No. 4, July 1990, pages 713-717, 7 Ref.

ABSTRACT

The results of preliminary tests in tritium and neutrons from palladium cathodes during D_20 electrolysis are presented. The few positive results obtained from many tests are discussed. Neutron and tritium signals are not obtained in the same experiment, but significant limits (5 X 10^5 to 1 X 10^7) are established for the tritium-to-neutron ratio due to the precision in tritium measurements and the stability of neutron detectors.

CONCLUSIONS

Various test in electrolysis with LiOH-D_2O and palladium cathodes were carried out. Some showed neutron production above the background. Careful tritium analysis performed in electrolytes and in recombined D_2O showed a tritium production that could not be explained by electrolytical enrichment only. Assuming that tritium and neutrons were obtained in the same tests, the tritium-to-neutron ratio should range between 5 X 10^5 and 10^7.

COMMENTS

One of the interesting precautions taken by the experimenters was the removal (by electrolysis) of metal traces from the electrolyte (using two Pd electrodes). Another pretreatment was the reduction of current to zero for 16 hours "which allows lithium surface incorporation into palladium cathodes".

FROM JAPAN - See article on page 1.

FROM RUSSIA - COLD FUSION POWER UNLIKELY

V. B. Brudanin, V. M. Bystritsky, V. G. Egorov, S. G. Shamsutdinov, A. L. Shyshkin, V. A. Stolupin and I. A. Yutlandov (Laboratory of Nuclear Problems, Joint Institute for Nuclear Research, Moscow, USSR), "Does Cold Nuclear Fusion Exist?", *Physics Letters A*, Vol. 146, No. 6, June 1990, 5 ref.

ABSTRACT

Results of the investigation of cold nuclear fusion on palladium are reported both for electrolysis of heavy water D_2O and a mixture D_2O + H_2O (1:1) and for palladium saturated with deuterium gas. The existence of this phenomenon was examined by detection of neutrons and gamma-quanta from the reactions d+d --> ^{3}He + 3.27 MeV, p + d --> ^{3}He + gamma (5.5 MeV), and by measuring the characteristic X-ray radiation of palladium due to the effect of charged products ^{3}He, p, t. The upper limits of the d-d and p-d fusion (partial) reaction rates are given by d + d --> ^{3}He + n, lambda_f less than or equal to 1.2 X 10^{-24} per sec., d+p --> ^{3}He + gamma, lambda_f less than or equal to 2.4 X 10^{-25} per sec. (both electrolysis); d + d --> ^{3}He + n, lambda_f less than or equal to 6 X 10^{-25} per sec. (gaseous phase).

CONCLUSION

The above considerations allow us to make the following conclusion. If cold nuclear fusion really occurs under the conditions existing during our investigations, its probability, nevertheless, is extremely small and it can hardly be a power source in the near future.

COMMENTS

The experimental cell used a cylinder of Pd supported between two (an outer and an inner) cylinders of Pt. The authors note that old Lithium salts may contain noticeable amounts of tritium and that regular calibration of neutron detectors by means of neutrons sources speed up tritium production. These two factors need to be guarded against. Advice to Russia: Try some new conditions. Ed.

RUSSIA - FUSION IN TITANIUM?

V. B. Brudanin, V. M. Bystritsky, V. G. Egorov, S. G. Shamsutdinov, A. L. Shyshkin, V. A. Stolupin and I. A. Yutlandov (Joint Institute for Nuclear Research, Laboratory of Nuclear Problems, Moscow, USSR), "Once More About Cold Fusion", *PHYSICS LETTER A*, Vol. 146, No. 6, June 1990, pages 351-356. 8 Ref.

ABSTRACT

Results of the experiments on the search for cold nuclear d-d fusion in chemically pure titanium are given both for electrolysis of heavy water D_2O and for titanium saturation with deuterium gas. The saturation took place at a temperature of 77 K and pressures of 50 and 150 atm. A series of experiments with temperature varying from 1 to 600 atm. was carried out. The limiting values of the partial rate of the nuclear reaction of d-d fusion with neutron production were obtained per deuteron pair (at 95% confidence level): lambda_f less than or equal to 8 X 10^{-25} s^{-1} (experiment with electrolysis); lambda_f less than or equal to 1.4 X 10^{-27} per second (experiment with deuterium gas).

DISCUSSION OF RESULTS

Taking into consideration the results obtained in this paper and in ref. 1 of the article, one can draw the following conclusion: if cold nuclear fusion really occurs, its probability in Pd and Ti under the above conditions is extremely small. Thus, it is practically impossible to observe this phenomenon in laboratories with an ordinary background level.

It is quite possible that the effects observed in refs. 2 & 3 of the article and ascribed to cold nuclear d-d fusion have another origin. It is known, for example, that during sorption-desorption of hydrogen by palladium, titanium and intermetallic compounds, their lattice undergoes changes accompanied by cracks. The following results are possible: total cracking when the shape is lost and a finely divided phase is produced; partial cracking (2-3 cracks) with the shape remaining or development of a single crack; absence of destruction signs on the surface of the sample.

In view of what was said above, one may put forward a hypothesis on the mechanism of the allegedly observed neutron production in the nuclear d-d fusion reaction. Fusion neutrons can be due to the fact that strong electric fields may occur in the developing cracks where deuterons are accelerated to the energies sufficient for the d-d fusion reaction to run. To test this hypothesis, one must experimentally investigate the time correlation of crack development and neutron appearance.

The acoustic emission method (AE) provides a real possibility of reliably fixing the moment of cracking of metal hydride samples. Fig. 5 of this article presents histograms for variation of AE parameters typical for the cases shown above. It should be mentioned that high-amplitude signals, appearing after the beginning of sample saturation with hydrogen, correspond to development of macrocracks in the sample. Consequently, using coincidence of signals from acoustic emission transducers and from neutron detectors, one can unambiguously test experimentally the above hypothesis on the d-d fusion mechanism. These experiments should, of course, be performed in special laboratories with a low level of neutron background.

According to the above hypothesis, the intensity of the hypothetical neutron source must quantitatively be in great dependence upon the technique of sample saturation with deuterium as well as upon many other experimental conditions. So the results obtained in different laboratories of the world will not seem surprising and controversial.

RESEARCH REPORT FROM SOUTH AFRICA

Paul du T. Van Der Merwe (Atomic Energy Corporation of SA, Ltd. South Africa), "Enhanced Fusion Induced By Affiliated Muons", *FUSION TECHNOLOGY*, VOL. 17, No. 4, July 1990, pages 696-703,8 ref.

ABSTRACT

The effect of cooperative action of pairs of affiliated muons on the fusion of hydrogen nuclear isotopes is discussed. The deuterium-tritium-muon-muon fusion rate is found to be enhanced more than tenfold relative to the single muon induced rate.

SUMMARY

It may be concluded that although the utilization of a phenomenological potential sacrifices accuracy in the calculated fusion rates, the thrust of enhanced fusion fashioned by affiliated muons can hardly be changed as the theory matures to a more rigorous four-body formulation.

COMMENTS

As a visitor to South Africa, it is recognized that this industrial nation (13th in the world) is the only major industrial nation in all of Africa. Several African nations border on or constitute an enclave within South Africa and look to South Africa for food, education, and technology. We are pleased that scientists from South Africa are participating in the development of cold fusion. With a combination of good technology and expert diplomacy, South Africa will be able to help improve the lot of many nations in Africa. Ed.

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D. SHORT ARTICLES FROM AUTHORS

BAND STATE DEUTERIUM FUSION
By DR. T. A. Chubb, Research Systems, Inc., Arlington, Virginia

ASSESSMENT OF OBSERVATIONS

The Mar. 1990 Utah conference on cold fusion revealed a wide variety of phenomena associated with deuterated Pd and Ti. Some of the observations were marginal and much of the theory not-too-well founded. To my view the interesting aspect of cold fusion is the original Fleischmann and Pons observation of nuclear heating without commensurate neutron, gamma ray, or ^3H production [1]. This nuclear heat release has also been observed at Stanford and Texas A & M, and by other groups [2]. The almost certain nuclear reaction product, then, must be ^4He, and the ^4He measurements reported by Worledge at the Utah meeting (see Table 4 in Reference 3) clearly showed substantially higher ^4He levels in cathodes that had been used in D_2O electrolysis (two sample cathodes with many analyzed segments) than in a control cathode from the same production batch that had not been used in electrolysis (one sample cathode with many analyzed segments).

A NEW PICTURE OF FUSION

Conversion of D + D directly into ^4He by collision or tunneling is impossible because the reaction violates the combined conservation of energy and momentum. On the other hand, creation of a collective deuteron state in a host metal or metal deuteride lattice is allowed, and is probably favored in stoichiometric PdD, as additional D is added [4,5]. Formation of band state deuterium avoids introduction of localized lattice strain, which is a major endothermic term in the Gibbs free energy.

BAND STATE DEUTERIUM

If band state deuterium forms, it has all the properties required to lead to ^4He production and lattice heating. In other words, it is nuclearly unstable and decays to ^4He by self-interaction [4,5,6]. Band state deuterium is describable by the same physics as used to describe a population of electrons in an n-type semiconductor. One writes down a many body wave function based on single particle wave functions in a periodic lattice, and combines possible representations in a manner that reflects the indistinguishability and exchange-symmetry of the component particles. The only difference between the collective state formed of bank state electrons, which describe the conduction properties of the n-type semiconductor, and the collective state formed of band state deuterons is the anti-symmetric exchange symmetry of the electrons, which are fermions, and the symmetric exchange symmetry of the deuterons, which are bosons. Once the many body wave function is written out, the key properties of the system follow.

As shown by my colleague Scott Chubb, there are two key properties of band state deuterium:

1. Its wave function contains terms which describe a low-duty-cycle transient multiple occupation of each of the unit cells of the host crystal, and

2. The transient multiple occupation terms fluctuate between chemical density configurations and nuclear

density configurations in accordance with the Fermi Golden Rule.

These properties are quantum-mechanical fluctuation properties of a collective matter state. The fluctuations are reversible and do not involve any release of energy. However, the fluctuation of the double occupation terms between chemical and nuclear density can include an interaction with a lattice nucleus, in which case the

fluctuation can transfer a displacement energy to the lattice atom, i.e. the fluctuation can heat the lattice. The end result of a sequence of energy transfer fluctuations is the collapse of the wave function of a product ^4He ion to form a localized ^4He wave function within one of the unit cells of the lattice. Alternatively, the fluctuation of the

4-fold occupation terms between chemical and nuclear density can in a single step generate two 23.8 MeV alpha particles with full conservation of energy and momentum. These alpha particles seem to have been observed in two experiments by Chambers et al. [7]. More generally, the fluctuations preserve Bose symmetry and obey a boson-in, boson-out selection rule [8].

IMPORTANCE OF ^{4}He

So, to be blunt, in my view, observations of neutrons, gamma rays, ^3He. etc. are peripheral. Such products are not to be expected in solid-state fusion. On the other hand, observation of the ^4He end product is crucial.

ALTERNATE APPROACHES TO COLD FUSION

The electrochemical approach to cold fusion may not be the best approach. This approach depends on surface poisoning of Pd cathode metal in order that non-equilibrium surface chemistry can achieve the internal D concentration needed for formation of band state deuterium. The ion implantation method of Chambers et al. [7], or the use of cold cathode discharge ion-loading methods may be easier. Of course, if a better means of poisoning Pd cathodes, so as to prevent atomic recombination were discovered, this opinion could be reversed.

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ABOUT THE AUTHOR

Dr. Talbot Chubb received an AB in Physics from Princeton University in 1944, and a PhD in Physics from the University of North Carolina in 1951. He retired from a career at the Naval Research Laboratory in 1981. He is a Fellow of the American Physical Society, a Fellow of the American Geophysical Union, and a Member of the American Astronomical Society. He received the Navy Distinguished Civilian Service Award in 1978, and is the author and co-author of over 60 papers in refered journals, and holder of over a dozen patents.

CAN MONOCRYSTALLINE PD-ELECTRODE HELP COLD FUSION?

By Professor M. Gryzinski

Not long ago I read in *Nature* a detailed report[1] describing the laborious search for cold fusion neutrons, and excess heat generation in $D_2$0-Pd cells. Supposing that the effect may depend upon the structure of the metallic electrodes, the authors of the report have used Pd-electrodes of various dimensions and shapes, made by means of different technologies. One can be surprised, but until now nobody has reported the use of a Pd-electrode made of a single crystal. It is hard to overestimate the role of regular crystallic structure upon the mechanism which is unknown. Nevertheless, this seems to be the only case whereby hydrogen can be introduced into a Pd-lattice in a controlled way (changing orientation of the crystal with respect to the electric field, for instance) and maintaining some order in filling of the lattice with hydrogen. This approach may be important as the cold fusion process may have its origin in a collective interaction among aligned hydrogen atoms (molecules) or in rapid transition from alpha- to beta-phase in the whole crystal.

The second alternative seems to be very likely, as much of the heat release reported by Pons and Fleischmann[2] was very rapid and apparently took place in the whole electrode volume, while in other experiments with polycrystalline Pd-electrodes) the emission of neutrons and release of heat had a form of spikes and/or bursts.

If cold fusion has a quasimolecular nature (as the author has suggested some time ago[3]) and electrons are really involved in bringing two nuclei together, energy of fusing nuclei may be released via electrons in the form of soft X-rays while emission of neutrons may be strongly suppressed, as not two but, three particles are involved in the process.

In view of the above it seems absolutely necessary, prior to drawing final conclusions about cold fusion, to carry out experiments with cathodes made of a single Pd-crystal and to look for soft X-rays.

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DECOUPLED ORBITAL SYSTEMS, SUPERCONDUCTORS, AND COLD FUSION.

By Richard M. Westfall Research Director, Galactic Mining Industries Inc.

ABSTRACT

This theoretical model, involving Decoupled Orbitals, is able to describe the behavior of both superconductors and cold deuterium fusion in palladium. In each case the model involves a rigid, strongly bound, structural

sublattice of atoms, and a permeating weakly-bound fermi gas where Bose-Einstein condensation of fermions to bosons takes place. In the case of superconductors, two electrons condense to form a Cooper Pair. In the case of cold fusion, two deuterons fuse to form a helium4 that exhibits superfluidity.

DISCUSSION

Superconductors are materials where conduction of electricity is unconstricted and the materials exhibit zero electrical resistance [1]. This behavior can be understood through what is known as the Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity. In the BCS theory, two electrons condense to form a Cooper Pair [2]. Electrons are particles which are classified as fermions, while a Cooper Pair is classified as a boson. This distinction between the particles involves the Pauli Exclusion Principle, which simply stated says that no two particles can exist in the same place at the same time. Fermions, such as electrons, obey the Pauli Exclusion Principle and so must wait in line as the electrons in front of it move down a wire.

Boson particles don't obey the Pauli Exclusion Principle, and so can exist in the same place at the same time. Cooper Pairs exhibiting superfluidic mobility have unconstricted ability to move. When a superconductor is cooled to below it's critical temperature, (Tc), the fermion population of conduction electrons condense forming Cooper Pairs which are bosons. The superfluidic mobility of the Cooper Pairs results in zero resistance to the flow of electrical current.

Superfluidity can be observed experimentally with helium4 liquid, which when cooled to a temperature near absolute zero, will flow through a semiporous membrane as if the semiporous membrane weren't constrictive to the flow of the helium4 liquid. The helium4 atoms are classified as bosons just as the Cooper Pairs are classified as bosons. When Cooper Pairs move through a super conductor, exhibiting no resistance to movement, we say that the material in a superconductor. When the helium4 flows without restriction through a semiporous membrane, we say that the helium4 is a superfluid.

Decoupled Orbital Systems

Decoupled Orbital theory will be shown to describe the behavior of two of the three types of superconductors, and will be used to describe experimental results obtained in cold fusion research. Superconductors and cold fusion are both shown to be a phenomena involving the Bose-Einstein condensation of fermions to bosons [3].

Decoupled Orbital systems such as intermetallic superconductors and ceramic oxide superconductors involve a rigid structural sublattice and a weakly-bound

electron cloud having distinct unshared eigenvalues. The rigid sublattice supports the thermal phonon spectra, with the permeating fermi cloud of conduction electrons able to undergo Bose-Einstein condensation, forming Cooper Pairs.

Deuterons permeating a palladium metal lattice are another decoupled orbital system. The deuterons act like a weakly-bound fermi gas, and are isolated from the thermal phonon spectra supported by the palladium metal lattice.

DETAILED DESCRIPTION:

Superconductors:

Superconductors can be grouped into three principle classifications:

1. Elemental superconductors such as niobium (Nb), which has a critical temperature near 10 degrees K.

2. Intermetallic alloy superconductors such as niobium tin, niobium germanium, and niobium aluminum, with critical temperatures near 20 degrees K.

3. Ceramic oxide superconductors such as yttrium barium copper oxide, bismuth strontium calcium copper oxide, and thallium barium calcium copper oxide, with critical temperatures as high as 125 degrees K.

The elemental superconductors such as niobium have Cooper Pair formation in conduction orbitals which share orbital elements with structural bonding orbitals, and so is unable to support Bose-Einstein condensation of electrons to Cooper Pairs at temperatures much elevated from absolute zero.

In both the other classes, the intermetallic alloy superconductors and the ceramic oxide superconductors, Cooper Pair formation occurs in conduction orbitals which are isolated to varying degrees from the structural rigid sublattice. The thermal phonon spectra supported by the rigid sublattice is isolated from the conduction orbitals where Bose-Einstein condensation occurs, and so boson formation is able to proceed at temperatures elevated from absolute zero.

The rigid sublattice of the intermetallic alloy superconductors, and the rigid sublattice of the ceramic oxide superconductors differ in their relative degrees of rigidity. The three dimensionally rigid sublattice of the ceramic oxide superconductors is significantly stiffer than the rigid sublattice comprised of Nb-Nb stick-like elements in the intermetallic alloy superconductors, and this can be shown to be why the critical temperature of the ceramic oxide superconductors is so much higher than the critical temperature of the intermetallic alloy superconductors.

The intermetallic alloy superconductors can be shown to be comprised of Nb-Nb stick-like elements, where one niobium atom with 4d5 orbital configuration is seen to form a hybrid bond with another niobium atom with 4d5 orbital configuration, resulting in a 4d10 hybrid orbital configuration. The tin, germanium, and aluminum alloying elements support the conduction orbitals where the Bose-Einstein condensation occurs. The isolation of the thermal phonon spectra within the rigid sublattice provides a thermally isolated environment for the conduction orbitals where Cooper Pair formation occurs.

The ceramic oxide superconductors have been found to consist of copper oxide, copper bismuth oxide, and copper thallium oxide rigid three dimensional lattices. The electropositive elements such as yttrium, strontium, barium, and calcium are interdispersed throughout these rigid three-dimensional lattices. These electropositivespecies support the conduction orbitals where the Cooper Pair formation occurs. The three-dimension rigid sublattices of this class of materials supports and isolates the thermal phonon spectra from the conduction orbitals where Cooper Pair formation occurs. The rigidity of these three-dimensions lattices can be shown to be responsible for the highly-elevated critical temperatures of these superconducting materials.

Cold Fusion

In the case of deuterium fusion in metallic palladium, the palladium metallic lattice supports the thermal phonon spectra. The permeating weakly-bound fermi gas of deuterons are isolated from the thermal phonon spectra and are able to undergo Bose-Einstein condensation (fusion), forming hot helium4 nuclei. In a plasma fusion system, hot helium4 atoms undergo fissile decay to helium3 and neutrons.

The palladium lattice contains the hot helium4 nuclei preventing their fissile decay to helium3 and neutrons. By absorbing the energy generated in the deuterium fusion to helium4 reaction, the helium4 nuclei are stabilized. The helium4 boson population exhibit superfluidic mobilities within the palladium metal lattice [4]. Melting of the palladium metal does not occur because the thermal energy is dissipated without local overheating by the superfluidic movement of the hot helium4 boson populations.

It has been observed that palladium cathodes which initially support the fusion of deuterium to helium4 ceases to function after a period of operation. Photomicrographs of such electrodes evidence the formation of small voids at the grain boundaries of such electrodes. When a hot helium4 nucleus exits one grain, containment is lost and a catastrophic fissile event occurs, as evidenced by the formation of the small voids at the grain boundaries. The formation of small voids due to this mechanism results in work hardening and deformation of the palladium metal and so causes the cessation of the observed fusion reactions. In this post deformation state the system no longer isolates the thermal phonon spectra from the weakly-bound fermi gas of deuterons and so Bose-Einstein condensations no longer occur.

Theoretically, single crystalline palladium would be able to support fusion of deuterium to helium4 without the loss of containment at grain boundaries and thus without the associated work hardening and deformation of the metal electrode. Damage to such electrodes through loss of containment of hot helium4 out of the surface of crystalline electrodes may be prevented through the use of electrode crystals of a minimum size or larger.

Other metals may also support cold fusion, such as titanium and niobium. A deuterium-loaded Titanium rod has been reported to be useful in cold fusion, with a group in Pocatello, Idaho researchers reporting such results. It is interesting to note that the Pocatello group achieved fusion upon cooling of the titanium gas-loaded rod, further suggesting a Bose-Einstein condensation mechanism.

CONCLUSION

Decoupled orbital systems have been shown to explain results obtained in superconductors and cold fusion. In both cases fermions undergo Bose-Einstein condensation reactions.

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It would seem that the theory may be applicable to a sea of deuterons within a metallic lattice. For it to apply, it would seem that the metallic lattice should be uniform over lengths equal to or larger than the coherent length between the deuterons which make up the pairs. D. Cravens.

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NUCLEAR SPIN AND MAGNETIC FIELDS

Nuclear Spin Alignment in Cold Fusion By Dr. Dennis Cravens

Although many laboratories around the world have declared the production of excess heat, there has been a general lack of reproducibility in such experiments. The difficulty of reproducibility does not seem to be dependent on a single factor, but instead upon a collection of small factors that enhance the likelihood of success. Some of these factors are procedural (e.g. not using current densities over 0.5A per sq cm; or working at temperatures below 30 degrees C). Some are materials (quality of D_2 and metals); and some are simply attention to detail and patience (such as insufficient short loading times). What is needed is an initial theoretical viewpoint from which to understand the cold fusion process and specific guidance in construction of practical devices.

The key to a theoretical viewpoint seems to be in viewing the process as a coherent and dynamic process. The lack of neutrons appears to be linked to selected or directed reaction pathways. This would seem to indicate that nuclear spin alignment is at work. It is known that alignment of nuclear spins can enhance nuclear cross sections for specific events [1]. Anti-aligned spins favor the neutron reaction pathways and parallel aligned nuclear spins favor production of ^{4}He (or meta stable ^{8}Be if ^{6}Li + D is involved). Further magnetic fields within paramagnetic metals can be locally very intense, especially along crystal domain interface.

It is well known that there is a rough correlation between the paramagnetic susceptibility of an element (such as Pd and Ti) and its ability to take up hydrogen/deuterium. Also, the paramagnetic susceptibility of the material drops as the hydrogen is absorbed within the metal lattice. The paramagmetic susceptibility of metal is determined by the spin of non-valance electrons within the metal. The change during loading can be shown to be related to the alignment of the nuclear spin of the absorbed hydrogen. The absorption of hydrogen on paramagnetic metals is used to produce para-hydrogen and deuterium [2]. The para form has a greater thermal conductivity and greater heat capacity than the ortho form. Ferric or paramagnetic catalysts are used to convert hydrogen to the para form to make storage of liquid hydrogen easier. Para hydrogen and deuterium has "spin-aligned nuclei" and is stable over a wide range. In fact, ortho and para forms are not quickly interconverted by heat up to their molecular dissociation temperatures.

With spin aligned nuclei of deuterium (and possibly ^{6}Li) it may be possible to produce coherent nuclear states. Unlike electrons (Fermions) which cannot occupy identical states with other electrons, deuterium and ^{6}Li are Bose particles which can occupy identical states. In fact, Bose statistics which govern these particles lead to enhanced probabilities that many Boson will occupy identical states. This is the same statistics which allow for lasers (coherent photons in the same state) and the super fluidity of ^{4}He. In such statistics, there is a reduced pressure of particles within a closed system and at a certain high density. This is called Bose condensation [3]. That is, all the above mentioned particles behave something like a saturated vapor. An increase in the amount of the substance merely increases the amount of the condensed phase (i.e. coherent state) without materially increasing the pressure. The particle density per average temperature is thus an important figure of merit for a given configuration.

Several general predictions can be made from this approach:

1) The loading to form nuclear aligned D and Li is critical.

2) The reactions are best done at elevated temperatures when the density of reacting particles is high.

3) Initiation of the process can be enhanced by either increasing current density or increasing temperature after the initial loading.

4) Anti-ferromagnetic impurities are to be avoided.

5) The presence of small amounts (ppm) of ferromagnetic materials may be beneficial.

6) Neutrons could be expected when the internal magnetic fields abruptly change (during heating, transitions past the curie point, during mechanical shocks or during large electromagnetic pulses).

7) The crystal structure of the cathode can be important.

8) There is an optimum crystal grain size (too small - no coherence; too large - no intense field at boundaries).

9) Use of ferromagnetic anodes (such as Ni) can alter the process.

10) Intense magnetic fields (especially during loading) may enhance the process.

11) Greater temperature should enhance the process but impair loading.

12) If lithium is involved, it is the ^{6}Li isotope (Bose particle) that is important and not the ^{7}Li.

13) If ^{6}Li is involved, the reaction channel is via excited ^{8}Beta (resolving to 2 ^{4}He) and we should look for those decay products.

14) The presence of magnetic fields during crystallization and annealing of the cathode may effect the process.

It is still not clear if the primary reaction is D + D or Li + D. The D+D reactions have been considered at great lengths. If spin alignment is taking place within the cathode, there is one ^{6}Li + D spin-aligned reaction that is especially interesting. The ^{6}Li + D level is 22.280 Mev above the ground state of ^{8}Be. This nearly matches the spin 2 + 22.20 Mev excited state of ^{8}Be. Unlike many ^{8}Be states, this one is stable with respect to disintegration into gamma emission. The even parity of the 2+ ^{8}Be state forces the ^{6}Li (d, alpha) ^{4}He reaction pathway. This leads directly to two ^{4}He particles with a combined energy of 22.2 Mev.

Note that the transition from ^{6}Li +D (22.2 Mev) to ^{8}Be transition is energetically allowed and near resonance. The 22.2Mev ^{8}Be to 2 ^{4}He transition would not be expected to produce gamma rays due to parity and spin restrictions. The reaction could be expected to have a large cross section at low energies. It would, however, require both ^{6}Li and D to be present within the cathode; both be in the spin +1 state; and both be aligned relative to each other. Should this process be the dominant heat production mode, pre-loading the cathode with ^{6}Li, or operating at elevated temperatures (say above 300 C to open lattice sites to Li) could be expected to enhance the process. Use of molten electrolytes, such as deuterated lithium (enriched ^{6}Li) bisulfate in the presence of magnetic fields (present during loading) would be expected to give enhanced energy production.

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ABOUT THE AUTHOR

Dr. Dennis Cravens is a professor at Vernon College, Vernon, Texas and a correspondent to *Fusion Facts*.

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SPIKING COLD FUSION

Who's Trying to "Spike" Cold Fusion Development?
by Marjorie Mazel Hecht, June 28, 1990

The latest attacks on cold fusion have come up with a new, disturbing argument: Any scientific experimental results that seem to contradict accepted theory must be the result of ***bold fraud***. To the scientific establishment, the fusion of hydrogen at room temperature is not possible, and therefore reported indications of such fusion must be experimental error -- or lies.

Thus, one of the most intriguing experimental results -- the production of tritium in cold fusion cells -- is now impugned as "fraud" in the science press. Tritium is a known product of a nuclear fusion reaction and therefore its presence in some cold fusion experiments is taken as proof that a nuclear reaction is occurring at room temperature. About 20 laboratories worldwide have detected tritium in some of their fusion cells. [See summary of tritium results in *Fusion Facts* for June 1990].
Leading the campaign to drown cold fusion in **deep fraud** is an article by freelance writer Gary Taubes in the June 15, 1990 issue of *Science*, the weekly magazine of the American Association for the Advancement of Science. Taubes, who is writing a book about cold fusion for Random House, admitted to this writer that it was most important to knock down the tritium findings because the presence of tritium was still convincing some mainstream scientists that cold fusion was real.

The article is benignly titled "Cold Fusion Conundrum at Texas A&M" and is carefully crafted to clothe its attack in academic robes. How should a university deal with allegations of scientific fraud?, Taubes asks, suggesting that at Texas A&M the administration could have done more to investigate rumors that someone "spiked" the cold fusion experiments with tritium.

"Was it truly a fusion reaction, which would require rewriting nuclear physics? Was it some inadvertent contamination? Or was it something more insidious?", Taubes asks. After five pages of gossipy details and innuendos about the lab and the scientists involved, the reader can have little doubt about the author's answer to his questions.

Now for my questions: Is it possible that the author is "contaminated" and that something more "insidious" is involved in this *Science* article? Or is this just a writer trying to gain fame by reporting controversy? To try to find out, I spoke with Gary Taubes and with some of the people he interviewed.

Taubes was sought out by Random House to write the book on Cold Fusion because of his reputation in handling "controversy" with a 1987 book on an Italian Nobel Laureate. Reportedly he has a $30,000 advance to carry out his task. Taubes would not confirm the amount (he was clearly annoyed that I had asked), but he said that nonfiction books on science now routinely had large advances, and he cited two advances he knew of at $60,000 and $275,000.

Taubes enunciated the status-quo line on cold fusion clearly: The strongest argument for "fraud" is the fact that cold fusion is not possible, given the laws of nuclear physics.

Taubes told me: "The most logical way to explain the way their data [on tritium] showed up was with somebody putting it [tritium] in the cell. Nobody wants to believe in fraud. It's the worst crime a scientist could commit virtually. ... Yet in this case it was the easiest, the simplest way to explain the data."

Despite Taubes's claims to objectivity, his bias against cold fusion was not hidden, even as early as two months after the first announcement of the phenomenon in March, 1989. The occasion was a Department of Energy conference on cold fusion in Santa Fe, New Mexico, in May, 1989; and the scene was a Mexican restaurant, where Taubes ostentatiously dropped an Alka Seltzer into a glass of water, proclaiming, "Behold, cold fusion."

Happily, despite the scorn heaped on cold fusion by some in the scientific establishment and by some of the media, the infant technology is still alive and kicking. Scientists around the world continue to make new discoveries about the process, theoreticians are suggesting new models to explain he phenomenon, and a cold-fusion-powered generator is promised within a year.

The jury may still be out on the questions: Who is trying to "spike" cold fusion development?; What is behind Gary Taubes and his book?; and why *Science* chose to publish such an antiscience article? There is no doubt, however, that it is a sad day for science when accusations of "fraud" can be used to chill development of a new technology that holds much promise for the betterment of mankind.

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PROTIUM TO DEUTERIUM - THEORY

A Protium to Deuterium Theory of Cold Fusion
By John N. White, Chapel Hill, N.C.

A number of scientists have detected excess heat in experiments where a palladium cathode was electrolytically loaded in heavy water. There is no known non-nuclear explanation for the large amount of excess heat seen in some experiments, yet no nuclear by-products have been found in the amounts expected to be produced by candidate nuclear reactions. According to the theory presented here, the excess heat is due to two protons and an electron reacting to form a deuteron and a neutrino. The protons are from light water contamination of the heavy water or from moisture in the air. Neither the deuteron nor the neutrino would have been noticed, and the proposed mechanism suggests that the energy would be transferred to the palladium by means of a large number of low energy photons.

According to the Schrodinger wave equations, a wave function wants to have its greatest amplitude at the deepest part of a potential well, but it also wants to spread out. Electrons near the nuclei of a solid state lattice will behave as if they are localized in a deep potential well, but electrons far from the nuclei will be in states that are spread out over a larger volume of the lattice. Note that the exclusion principle forbids any two electrons from being in the same quantum state, but it does not prevent wave functions from overlapping.

The desire of a wave function to spread out is inversely related to the mass of a particle. A light particle, like an electron, has a very strong tendency to spread out. A proton will tend to settle into the deepest part of a potential well, but will spread out if the well is shallow enough.

In the case of a palladium lattice, when hydrogen nuclei are added they will sit in the potential wells formed by the face-centered-cubic crystal structure. But after a loading factor [Pd/D ratio] of 1 has been reached, all these wells will be occupied. If more hydrogen is added, where will it go? There are other potential minima that could be occupied, but if these are shallow enough and the barriers in between them low enough, then the Schrodinger equation will cause the wave function of the protons to spread out and simultaneously occupy all the wells in a large volume. If a number of protons are added they will occupy the same set of wells, with their wave functions overlapping. Electrons do this sort of thing all the time in solid state lattices. But because of their higher mass, protons will only do this if the strict condition of shallow wells with low barriers is met.

But if protons are reacting, why do experimenters see excess heat with D_2O but not H_2O? The explanation is that the voltage drop between the palladium electrode and the electrolyte is known to be higher for D_2O than it is for H_2O. This higher potential could make it easier to reach a loading factor greater than one. Also, it may be that PdH is not as good as PdD at meeting the requirements for causing additional protons to enter the delocalized state. Note that the wave function of a deuteron will not spread out as much as that of a proton because its mass is larger. This can explain why D+D and D+P reactions are suppressed. A prediction: in a closed cell calorimeter with the total protium impurity in the electrodes and electrolyte limited, the total amount of excess heat cannot exceed what would be expected from fusing all of that protium impurity into deuterium.

Actually, I have heard rumors of excess heat with H_2O. But anyone getting such a result would consider it an embarrassment because of the widespread misconception that this is impossible. Thus, these researchers want to find conditions where D_2O gives excess heat but H_2O does not. {Note: Matsumoto [1] has shown that cold fusion can take place in ordinary water. Ed.}

Consider the classic example of a particle confined in a square one-dimensional potential well. The wave function wants to spread out, but it also wants to remain smooth. So instead of abruptly dropping to zero at the edge of the well, it will decline near the edge and slide smoothly to zero outside the well. This means that there is an amplitude of finding the particle outside the well, where the particle does not have enough energy to be.

For a real particle, there is another "dimension" that the wave function can spread out in -- particle type. The wave function of a proton wants to spread out and have an amplitude of being a W+ and a neutron. This amplitude will be very small because of the huge mass of the W+. But the W+ will then produce an amplitude of a positron and a neutrino. So the wave function of a pure proton is not static, but will spread out over time into a wave function that has an amplitude for being a proton, neutron, positron, and neutrino. Note that all this is still the wave function of a single entity. The neutron amplitude will be rather small, due to the mass difference between a proton and a neutron. If you "test" for the neutron by bringing another proton near and seeing if you get a deuteron, then the probability of finding a neutron is extremely small (since it is the square of the rather small amplitude). After such a test the amplitude of being a neutron is reset to zero (assuming the test saw a proton).

Now consider what happens to the static, spread out, overlapping protons. Instead of a positron component, the wave functions of the electrons in the region will be reduced. This lowers the mass penalty of the neutron state. But having a neutron wave function spread out over other protons is not a static situation. Those protons are potential wells, and the neutron wave function will build up in these wells. In effect, the fact that most of the neutron part of the wave function is in a bunch of potential wells causes the neutron state to be more energetically favorable than the proton state. This allows the proton to decay into a neutron, just as a proton will decay into a neutron in a proton-rich nucleus. This decay will involve electron capture rather than positron emission because the proton wave function is spread out over a lot of electron wave function. A similar suppression of positron emission is seen in isotopes of high atomic number, where a substantial amount of electron wave function is within the nucleus.

But after the proton decays into a neutron, where is it? The neutron part of the wave function was spread out over a large number of protons. The energy due to binding the neutron is associated with the wave function. Thus, the excess energy of the reaction is spread out over a large number of protons. The system must dispose of the excess energy. There is a neutrino hanging around that can carry off the energy from one of these protons, but the rest of the energy must radiate as electromagnetic radiation. The energy of these photons depends on the number of protons involved, but might be in the soft X-ray region. Eventually, the wave function will "collapse", with the neutron picking one of the protons to be bound to.

There is a problem with getting the neutron part of the wave function to see the other protons. Coulombic repulsion would be expected to cause an anti-correlation in the position of the protons, and presumably the neutron part of the wave function would stay close to the proton part. One way around this problem would be to assume that the neutron part does not share the anti-correlation. An advantage of this assumption is that neutrons reacting with deuterium would produce tritium. However, I have not been able to find any basis in Quantum Theory for this assumption.

I am currently considering the possibility that there is actually a significant amplitude that the protons will be near each other. At close range protons are attracted to each other by the strong force. This attractive force is not strong enough to create a bound state, but under conditions that might occur in deuterium-loaded palladium, this force could result in a significant

probability for the protons to be very close together. This positioning, in turn, would let the neutron part of the wave function see the potential wells of the other protons.
Where else might the fusion of protons to make deuterium (P+e+P --> D+nu) occur? One possibility is in the middle of Jupiter. Under those conditions hydrogen is believed to be compressed into a dense metallic solid form. This environment could allow the necessary conditions for fusion, and indeed Jupiter radiates a lot more energy than it receives from the sun.

The conventional explanation for Jupiter's excess heat is that the heat was locked in during Jupiter's formation, and that as Jupiter cools, it contracts, generating more heat. This theory requires some optimistic assumptions. Saturn is even more interesting. It radiates more than twice the energy that it receives from the sun, and even optimistic assumptions cannot explain this. There is an attempt to explain this excess heat as being generated by helium diffusing to the center of the planet, but the argument is not convincing. I propose that cold fusion (P+e+P --> D+nu) is generating the excess heat in Jupiter and Saturn.

There is yet another interesting star in our solar system, the big bright one at the center. The core of the sun is plenty dense, but the extremely high temperature would inhibit the cold fusion mechanism. Still, a small increase in the rate of fusion might occur. If this effect is significant, then the observed rate of reaction in the sun would occur at a lower temperature than is currently believed. Neutrino detectors only see 1/3 the expected flux, but these detectors are only sensitive to neutrinos produced by an extremely temperature-dependent side reaction. I propose that this neutrino deficit is due to the temperature inside the sun being cooler than is currently believed, which is made possible by the CNF effect. Note that competing CNF theories that consume deuterium can't explain the neutrino deficit, since any deuterium produced inside the sun is instantly consumed anyway.

The earth also produces excess heat, but this fact is easily explained by assuming sufficient amounts of uranium and thorium inside the earth. However, the concentration of deuterium in the earth's oceans is about five times the cosmic abundance. It is proposed that this abundance is due to 4 billion years of P+e+P --> D+nu fusion reactions. Note that only a reaction that produces deuterium can explain this anomaly.

In summary, the P+e+P --> D+nu cold fusion reaction can explain the observed excess heat, and can provide a natural explanation for the excess heat of Jupiter and Saturn, the neutrino deficit of the sun, and the excess deuterium on earth.

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ABOUT THE AUTHOR

John N. White has a degree in Physics from the University of No. Carolina and a Master's degree in EE from Duke University. He is currently involved in computer research as an independent investigator. His father is a professor emeritus from the U. of No. Carolina. Mr. White submitted this paper at our request after reading some of his comments on a computer network. Both the author and *Fusion Facts* would greatly appreciate any comments on the ideas presented here. Ed.

HOT FUSION COMPETITION

MAGNETIC FUSION SUBCOMMITTEE SETS GOAL OF 2025 FOR FUSION POWER PLANT

By Marjorie Mazel Hecht

The magnetic fusion energy subcommittee of the Department of Energy's Fusion Policy Advisory Committee met May 24-25, 1990 in Washington, D.C., and proposed to have the full committee adopt an agressive plan to move fusion into an energy-producing phase for the 21st century. The subcommittee set a date of 2025 for a fusion power plant.

The plan is a far cry from the crash program approach adopted in the 1980 fusion legislation and killed in the past decade, which would have built an engineering reactor by 1990 and a commercial plant by 2000. Nevertheless, the plan presented by Dr. Harold K. Forsen, senior vice president of the Bechtel Group, was light years ahead of the department's current approach: "Go slow and don't build any new device until you are sure it will work perfectly."

In 1989, the DoE removed funding in the budget for the Compact Ignition Torus (CIT), the next step planned in the U. S. fusion program. Instead DoE proposed a "competition" between magnetic and inertial confinement before the design of an engineering device is selected, and a committee to "study" the magnetic fusion program.

Forsen counterposed the pessimistic approach of the DoE to the "very impressive, steadily improving progress" the magnetic confinement program has made in the past decade. The physics basis exists, he said, to move now to a plasma-burning device like the CIT.

FUSION BY 2005

A fusion power pilot plant that generates electricity by 2005 was proposed by Dr. Stephen O. Dean of Fusion Power Associates and other fusion scientists in what they called the Accelerated Fusion Power Development Initiative.

The proposal for a 100-megawatt plant has an estimated total cost of $15 billion, which represents a savings of several billion dollars over the current DoE plan because of the efficiencies gained with a faster time schedule. Dean et al. suggested that a National Energy Technology Development Trust Fund could obtain funding from a small tax on fossil fuel consumption in order to make the necessary increases in the fusion budget.

The proposal was distributed at the Washington meeting of the magnetic fusion subcommittee meeting.

SOVIETS URGE U.S. SUPPORT FOR INTERNATIONAL FUSION REACTOR

Soviet Academician E.P. Velikhov gave a press conference in Washington, D.C., May 16, 1990, to urge U.S. support for the International Thermonuclear Experimental Reactor, ITER, a next-generation tokamak fusion experiment planned as an international collaborative venture by the United States, Soviet Union, Europe, and Japan.

ITER was first proposed by Soviet President Gorbachev at the Geneva summit meeting with President Reagan in 1985. The four collaborators have been working together since 1988 under the auspicies of the International Atomic Energy Agency to design a device that would demonstrate the scientific and technological principles of fusion power. In order to proceed with the multi-billion-dollar project, each of the four participants must now commit themselves to funding about $1 billion each over the next 10 years.

Europe and Japan both have plans to go ahead with their own engineering test reactors domestically; the Soviets have looked to ITER to push ahead their stalled program; and in the United States, some have argued that the international program could take the place of the under-funded and thus-stalled fusion program. The U.S. decision awaits the report of yet another committee appointed by Energy Secretary Watkins to "study" the fusion program and make recommendations by September 1990.

Velikhov, Vice President of the Soviet Academy of Sciences and director of the Kurchatove Institute of Atomic Energy, was in Washington "to promote East-West cooperation in science and technology," and ITER is high on the Soviet list of key projects. His press conference was sponsored by Fusion Power Associates, an industry group.

ABOUT THE AUTHOR

Marge Hecht is Managing Editor of *21st Century Science and Technology*. She has worked as a professional science editor and journalist in the vicinity of Washington D.C. for many years. She recognizes the tremendous potential of fusion energy (both hot and cold) and is a strong supporter of the reality of cold fusion.

E. COMING COLD FUSION CONFERENCES

45th ANNUAL CALORIMETRY CONFERENCE
(Courtesy of Prof. Jonathan Phillips)

Dr. Phillips writes: "We hope you will consider participating in the Application of Calorimetry to Electrochemical Processes session of the 45th Annual Calorimetry Conference. The conference will be held from July 22-27, 1990 at the University of Michigan in Ann Arbor. A lot of the controversy has arisen because of poor understanding of the calorimetric technique. In fact, the time is ripe to bring people together to discuss the new calorimetric technology as well as current and "potential" applications of that technology!"

CONTACT THE FOLLOWING:
Prof. Ron D. Weir, Dept. of Chem and Chem Engr'g.
Royal Military College of Canada - Kingston, Ontario K7K 5L0 Canada. Phone 613/541-6612 or Fax 613/547-3053 or WEIRR@RMS.BITNET

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The registration fee for the 1990 conference is $25 per person for the conference and luncheon or $10 for the luncheon session alone. For registration, speaker, and agenda information contact the Utah Engineering Experiment Station, 104 Engineering and Mines Research Office Building, University of Utah, 84112, phone 801/581-6348.

WORLD HYDROGEN ENERGY CONFERENCE #8

This conference will be held in Hawaii from July 23 - 25, 1990. A full report from this conference will be in the August issue of *Fusion Facts.*

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Abstracts should be sent to:

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Above information courtesy of Dr. Nate Hoffman of the Energy Technology Engineering Center who is the Conference Secretary.

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