FUSION facts

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CONTENTS FOR MAY 1990

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A. NCFI NAMES VISITING SCIENTISTS

UTAH FUSION INSTITUTE ANNOUNCES VISITING SCIENTIST APPOINTMENTS

PROMINENT SCIENTISTS FROM MALAYSIA, POLAND, SOUTH DAKOTA FILL FIRST SLOTS.

The National Cold Fusion Institute (NCFI) officially announced the first three appointments in its Visiting Scientist Program. The appointees are Dr. Krystyna Cedzynska, associate professor of inorganic chemistry and analytical chemistry at the Technical University of Lodz in Poland; Dr. Chee Yan Chan, associate professor of physical chemistry at the University of Malaya in Kuala Lumpur, Malaysia; and Dr. Robb M. Winter, associate professor of chemical engineering at South Dakota School of Mines & Technology in Rapid City, S.D. Dr. Fritz G. Will, institute director, says Chan's appointment is for six months and Cedzynska's and Winter's appointments are for one year. The program was established to bring distinguished American and foreign scientists to the institute to collaborate with U of U researchers on cold fusion experiments. NCFI, an independent, non-profit research institute affiliated with the University of Utah was established last August in the University's Research Park. The state of Utah appropriated $5 million to open and operate the institute, which is doing research aimed at broadening the scientific understanding of the cold fusion phenomenon and explore its potential commercial application.

A recent anonymous gift of $500,000 will allow the institute to expand the Visiting Scientist Program beyond the original expectations, says Will. The appointments are open to professors and/or scientists who are either active in cold fusion research or whose scientific background in related fields would make them strong contributors in a wide range of cold fusion studies. Additional appointments are expected to be announced soon.

Dr. Cedzynska is currently on leave from the teaching faculty at the Institute of General Chemistry at Lodz University. Lodz is Poland's second largest city. Cedzynska first taught at the Polish Institute from 1969 to 1979. She began working at NCFI in early March and will return to Poland in March 1991.

During the past 10 years, most of her research has been in electrochemistry, including studies of physical and chemical properties of lithium, zinc-bromine and other batteries. She earned a Ph.D. at Lodz in the synthesis of complex compounds of metals. Cedzynska has taught and done research at the Slovak Technical University in Czechoslovakia; Murdoch University in Perth, Australia; and the Melbourne College of Advanced Education in Melbourne, Australia. She has done research with CSIRO, the Commonwealth Scientific Industrial Research Organization, in Melbourne.

In 1982, she was admitted to the Royal Australian Chemical Institute as an associate member. She is also a member of the Polish Chemical Society, one of the oldest such groups in Europe.

Dr. Chan is a specialist in the thermodynamics of electrolytic solutions. He had done research on tin corrosion, and is currently looking at electrochemical methods of synthesizing organo-tin compounds for use as catalytic agents and agrocides. At the Utah institute, he is collaborating with cold fusion pioneers B. Stanley Pons and Martin Fleischmann on high-pressure experiments involving deuterium-palladium electrodes.

Educated in New Zealand, where he earned a Ph.D. in physical chemistry at Otago University in Dunedin, Chan has done research at the University of Florida, the University of Salford in Salford, England, and the Imperial College of Science and Technology in London.

Chan serves on a commission subcommittee on solid solubilities of the London-based International Union of Pure and Applied Chemistry. In cooperation with a scientific group from the Soviet Union, he jointly edited a volume of the solubility systems of alkaline earth metal perchlorates. The volume is part of the International Union's Solubility Data Series.

Dr. Winter has worked with U of U engineers on cold fusion-related projects since last May. The research has focused on developing accurate flow-through calorimetry for closed-system eletrochemical cells.

Winter joined the South Dakota School of Mines & Technology faculty in January 1989. From 1984 to 1988 he worked for General Electric Co., first as a staff engineer in corporate research and development and later on major polymer process development projects. He won GE managerial awards in 1985 and 1987.

Winter graduated summa cum laude from Dickinson State University in North Dakota in 1978. He earned his master's and Ph.D. degrees in chemical engineering at the University of Utah. He is also a member of the American Institute of Chemical Engineers and the Society of Plastics Engineers.

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B. FUSION NEWS FROM U. S.

THE NATIONAL COLD FUSION INSTITUTE

Researchers at the NCFI are making progress in understanding the fusion cell parameters associated with excess heat production claimed Dr. Fritz G. Will, the NCFI director. Parameters being systematically investigated by the current 32-cell experiments are: the size of the palladium cathode; the ambient temperature; the pH of the electrolyte; the concentration of the electrolyte; and the electrical current density.

Twenty-four out of the 32 cells produce excess heat ranging from 5% to 20%. Eight cells do not produce excess heat (due to cell parameters used). The cell temperature and the electrical current density has appeared to have had the strongest effect(s) on the production of excess heat.

Other experimenters are investigating certain categories of "poisons" (which can control the D/Pd ratio in the Pd cathode). A new team is now investigating surface chemistry associated with working cells. Others are preparing equipment to assist in the production and preparation of cell cathodes. The engineering group has designed an improved flow-through calorimeter. Dr. Haven Bergeson is beginning work on a collaborative effort with Dr. Steven Jones of BYU which will include measurements (deep underground) of fusion-cell produced charged nuclear particles.

NCFI SEEKING DEVELOPMENT FUNDS

Tim Fitzpatrick, "Prospectus on Fusion Leaks Out", Salt Lake Tribune, May 10, 1990, page B-1.

The National Cold Fusion Institute (U of U Research Park) is offering to "sell up to 20% of cold fusion's profits" to raise $15 million to fund research over the next three years. A prospectus has been prepared showing how the institute would offer a two percent of future profits in exchange for $1.5 million.

To date, no agreements have been signed with any investors, but one investor has shown significant interest, according to Dr. Will, the NCFI director. A prospectus has been sent to three interested companies and seven more will be sent out in the near future.

A LOS ALAMOS SUMMARY

The following chart shows positive results achieved in cold fusion experiments. This list was obtained from Dr. Edmund Storms from the Los Alamos National Laboratory.

POSITIVE RESULTS OF COLD FUSION EXPERIMENTS

Study	Tritium	Neutrons	Heat
Pons & Fleishmann (U. of Utah)	Y	?	Y
Jones (BYU)	?	Y	?
Bockris, et al. (Texas A&M)	Y	?	Y
Wolf (Texas A&M)	Y	Y	?
Appleby, et al. (Texas A&M)	N	?	Y
Schoessow (U. of Florida)	Y	Y	Y
Iyengar (India, BARC)	Y	Y	?
Huggins et al. (Stanford)	?	?	Y
Mathews et al. (India, IGCAR)	?	Y	Y
Adams (U. of Ottawa)	Y	?	Y
McKubre (SRI)	Y	?	Y
Scanchez et al. (U. Auton. de Madrid)	Y	Y	?
Oriani (U. of Minnesota)	?	?	Y
Scott, et al (ORNL)	Y	?	Y
Wada et al. (Nogoya U. Japan)	?	Y	?
Tanigucho et al. (OPRRI, Japan)	?	Protons	
Celani et al. (INFN, Italy)	?	Y	?
Alqasmi (Arab Emirates U.)	Y	Y	?
McBreen (Brookhaven Nat. Lab.)	Y	?	Y
Yeager, et al. (Case Western)	Y	?	Y
Jorno (U. of Rochester)	?	Y	?
Storms & Talcott (LANL)	Y	?	?
Menlove (LANL)	?	Y	?
Claytor, et al. (LANL)	Y	Y	?
Scaramuzzi, et al. (Frascati, Italy)	Y	Y	?
Bertin et al. (at Bologna)	?	Y	?
Droege (at home)	?	?	Y
Hutchinson (ORNL)	?	?	Y
Bush (Cal. Poly U)	?	?	Y
Wodsworth et al. (U. of Utah)	?	?	Y
Miles et al. (Naval Weapons Center)	?	?	Y
Gozzi, et al. (Univ. of Rome)	Y	Y	Y
Santhanam et al. (Tata Inst., India)	?	?	Y

MIT - HAGELSTEIN'S THEORY
(Courtesy of the author)

Peter L. Hagelstein (MIT), "Status of Coherent Fusion Theory", Presented at First Annual Conference on Cold Fusion, March 28-31, 1990, Salt Lake City, Utah, 20 pages, 94 ref.

ABSTRACT

Nuclear reactions which may exhibit coherent effects have been studied as a candidate explanation for cold fusion effects. An analysis of a general class of two-step coherent reactions involving charged nucleons has been performed, and very small reaction rates are found. This result is due to the small tunneling factors associated with coulomb repulsion. We are investigating two-step coherent reactions which begin through weak interaction mediated

electron capture, which in hydrogen isotopes would produce off-shell (virtual) neutrons. No coulomb repulsion occurs for virtual neutrons. Virtual neutron capture by deuterons would yield tritium and virtual neutron capture by protons would yield deuterons; the latter process is favored by a factor of 104 in the square of the matrix element on a per nucleon basis, and corresponds to a heat-producing reaction. The nuclear reaction energy would be coupled into the electrolysis process, with the final reaction products stationary. We have found that the weak interaction process can in principle be superradiant in the Dicke sense. If so, then considerable acceleration of this type of coherent reaction may occur.

NOTE: Hagelstein's review of the current state of cold fusion is the best we have found and is reprinted below by permission of the author and the NCFI. Ed.

INTRODUCTION

Much controversy has surrounded the area of cold fusion research since its inception last March following the initial papers of Fleischmann and Pons at the U of U and Jones et al. at BYU. During the months that followed numerous experiments were performed, most of which did not reproduce any of the various "miracles" that have become associated with cold fusion. Especially disconcerting was the apparent inability of the principle advocates of cold fusion to reproduce their own results.

Based on these points, and based also on the complete lack of any supporting theory or basic mechanism, the scientific community views cold fusion research of any sort with extreme skepticism. The ERAB review board politely summarized this position with the comment: "Based on these many negative results and the marginal statistical significance of reported positive results, the Panel concludes that the present evidence for the discovery of a new nuclear process termed cold fusion is not persuasive." Nature has gone further and has published a number of obituaries for cold fusion.

The arguments that have been given for the fundamental unsoundness of cold fusion research in general are numerous. Among them is the basic physics problem associated with overcoming the coulomb barrier at room temperature, and accounting for heat with no apparent nuclear byproducts. Additionally, the positive cold fusion results appear to be in direct contradiction to very basic precepts of nuclear physics, and it seems that an extremely fundamental and totally unexpected change in our understanding of physics would be required even to begin accounting for the various "miracles" that have been claimed. Finally, it has been remarked in private countless times that the single strongest arguments against cold fusion is that the experimental effects simply vanish whenever a competent physicist performs the relevant measurements with adequate instrumentation, and that anyone claiming to observe a positive result is self-deluding.

In spite of the views of the majority of physicists, positive experimental results in support of anomalous effects persist (as described in a recent review by Bockris). Evidence for very substantial excess heat generation in closed system calorimetry experiments has been obtained at Stanford. The isoperibolic calorimeter is simple and well-calibrated; the error bars are at the 1% level, and the signals exceed 20%. This evidence is compelling. Observations of heat have been reported by numerous other laboratories.

Perhaps the strongest evidence for substantial tritium production comes from Texas A&M. Additionally, tritium production has been reported numerous times. Neutron emission in electrolysis cells has been reported by BYU, and has been claimed at other laboratories. Neutron emission in gas cells has been reported by Frascati (who have recently seen more neutrons), LANL, and elsewhere. Fast protons have been reported in Ref. 51 in the paper. Heat bursts have been reported by many workers. Pons and Fleischmann reported early on in their work that a cubic centimeter cube exploded. Bockris mentions exploding rods in his review. Extreme heat production was reported by Gozzi et al., in a non-reproduced experiment.

There are proponents of cold fusion and there are skeptics. The skeptics have demonstrated that no cold fusion effects occur. The proponents have answered most if not all of the skeptics criticisms with respect to experimental methodology, and have demonstrated that the effects are real. Unfortunately the skeptics and proponents rarely meet and discuss physics, and this is very unfortunate for all involved.

We have adopted the position of devil's advocate (relatively). We have looked at the problem from the point of view that the effect may both be real and be all that was originally claimed for it, and from there inquired how it could possibly come about, without breaking basic physical laws in the process. The current experimental evidence from the proponents largely supports such a view, even at this late date after the obituaries have appeared in print.

We have speculated given the assumptions that the heat is real and of nuclear origin. It seems to follow that if the heat is real and accurately measured, that it must be nuclear since the total energy production that is reported would correspond to more than 10eV per atom of electrode. Additionally, if the tritium production is real, it most certainly involves nuclear processes since tritium cannot be made chemically. Finally, if the neutrons are

real, then they too would provide evidence for the occurrence of a nuclear process.

But what nuclear process? Certainly conventional binary nuclear reactions cannot do it, for two compelling reasons:

(1) there is no way known to overcome the coulomb barrier at room temperature to the degree required under electrolysis conditions, and

(2) there is no experimental support for any known conventional reaction that can produce either heat or tritium as it is reportedly produced.

Furthermore, if the tritium is real at the levels reported, and if it is actually produced with a low accompanying secondary 14 MeV neutron emission rate that it is smaller by many orders of magnitude as is reported, then it implies a very severe constraint on the final state tritium kinetic energy that may occur. This constraint is described in this paper, and more or less implies that no conventional binary fusion reaction is likely to be responsible, since the tritium which is produced is essentially sitting still by nuclear standards.

Another constraint must be obeyed by any nuclear reaction that is proposed to account for the "miracles." Not only do the reactions have to be consistent with the observed stability of heavy water and deuterium gas not involved in cold fusion experiments, but they must be consistent with stellar evolution models. The existence of a binary fusion reaction that occurs at room temperature would in all probability be impossible to reconcile with stellar models at higher temperatures.

Our general approach has been to explore what we have termed coherent nuclear reactions. These are proposed reactions that would proceed collectively due to some unique feature of the reaction, and occur only rarely as incoherent or binary reactions. Such reactions certainly can be postulated and are certainly physical, but most occur with an utterly negligible reaction rate. To our knowledge there is no previous work or speculation on such reactions; aside from the recent cold fusion results there would be no motivation aside from curiosity to explore collective nuclear reactions.

Our initial efforts involved the consideration the implications of coherent d-d reactions between coupled nuclear/lattice states that were degenerate. The idea is interesting, but finding microscopic mechanisms that support such a picture has been difficult. We analyzed a rather general class of coherent fusion reactions between charged hydrogen isotopes, and we were able to show that all such reactions in general occur with reaction rates that are quite small. The basic problem is that the matrix elements between initial and final states are too small due to support reaction rates in the range of those reported.

One solution to this very general problem is to consider coherent reactions wherein the fusion occurs between a neutral nucleon (neutron) and a charged nucleon. The weak interaction can provide a mechanism to reduce the charge of a hydrogen isotope, and the resulting problem becomes one of studying virtual neutron states, since the process is by necessity off-shell. A weakness of the approach is that one very difficult problem is replaced by another very difficult problem: that off-shell neutrons almost never stray far from their point of origin.

A second perceived weakness of the approach is that a reaction that begins with a weak interaction matrix element is probably going to be vanishingly small. We have found, or so we believe, an interesting situation in which a coherence effect has the potential to enhance neutrino emission (and therefore the effective strength of the weak interaction) by a large factor. This effect can be described briefly as Dicke superradiance of neutrinos. If it occurs, a condition that must be obeyed is that the final nucleon states be stationary. This condition is consistent with the constraint imposed by the low neutron emission observations during heat generation and tritium production. In order for this condition to occur, the nuclear energy must be transferred elsewhere in a nondisruptive manner, a process which has no precedent in nuclear physics.

COMMENTS

Hagelstein develops his theory with the fuel for the heat production being protons, deuterons, and electrons. The palladium acts as a sort of a catalyst. The theoretical results are in keeping with current observations. More important, the theory suggests several experiments which can support or disprove the theory. The paper is recommended. The paper will be printed in the forthcoming (expected about July 1990) Proceedings of the First Annual Conference on Cold Fusion. Ed.

THEORY PAPER: FUSION MORE POSSIBLE.
(Courtesy Geo. Miley, Ed. Fusion Technology)

Michael Danow (Nat'l Inst. of Standards and Tech), "Coulomb-Assisted Cold Fusion in Solids", *Fusion Technology*, May 1990, p 484, 6 pgs, 15 refs.

ABSTRACT

In a process where fusion leads directly to the ground state of the final nucleus, which requires the presence of a third nucleus, the regular and irregular coulomb solutions conspire to dramatically increase the coulomb

barrier penetration. The characteristics of this effect, and the limits of its validity, are described.

SUMMARY

In summary, we have indicated that a mechanism exists that has the potential of leading to a dramatic enhancement of the penetrability through the coulomb barrier, thus allowing for a substantially increased cold fusion rate. In this way, the factors that limit the rate in this mechanism turn out to lie not in the coulomb barrier but in other aspects of the quantum character of the system, in particular in the details of the density matrix describing the system and in geometric correlations of the participating nuclei. An exact evaluation of these effects would require the knowledge of very subtle characteristics of solids. Conversely, any quantitative observations of actual fusion reactions would yield information on these characteristics upon having ascertained which of the possible fusion reactions actually take place.

COMMENTS

The author prepares this study as "first steps" within conventional physics. The author is convincing that these first steps could lead to a better understanding of the process of cold fusion. The main problem is that the treatment of a three-body problem, in general, is performed usually by numerical techniques and the mathematics is difficult to relate to the physics of the process. Reading of the paper is recommended.

FUSION/FISSION CHAIN REACTIONS
(Courtesy Geo. Miley, Ed. *Fusion Technology*)

Samim Anghaie (U/Fla), Piotr Froelich (Uppsala U., Sweden), Hendrik J. Monkhorst (U/Fla), "On Fusion/Fission Chain Reactions in the Fleischmann-Pons 'Cold Fusion' Experiment", *Fusion Technology*, Vol 17, No 3, May 1990, pp 500-506, 11 refs.

ABSTRACT

The possibility of fusion/fission chain reactions following d-d source reactions in electrochemical "cold fusion" experiments has been investigated. The recycling factors for the charged particles in fusion reactions with consumable nuclei deuteron, ^{6}Li and ^{7}Li, are estimated. It is concluded that, based on the established nuclear fusion cross sections and electronic stopping power, the recycling factor is four to five orders of magnitude less than required for close to critical conditions. It is argued that the cross generation of charged particles by neutrons does not play a significant role in this process, even if increased densities at the surface of electrodes do occur.

CONCLUSIONS

We can summarize our results as follows:

1. Based on known fusion cross sections, fusion energies, and particle number densities in the system, the probability of achieving any form of self-sustained fusion/fission reactions is four to five orders of magnitude less than required for critical conditions.

2. If such cycling reactions would have taken place, then heat generation could have been explained without direct correspondence to the rate of triton and neutron productions.

3. As evidenced by the who host of reactions in Fig. 1 through Fig. 4 in the paper, the rate of ^{4}He production should directly correlate to the heat generation. Therefore, any "cold fusion experiment" reporting steady heat generation should look for abnormal levels of ^{4}He.

COMMENTS

The author presents a list of about 30 nuclear reactions that can be considered for possible occurrence in a cold fusion electrochemical cell.

PURDUE - D-D CROSS SECTION
(Courtesy Geo. Miley, Ed. *Fusion Technology*)

Yeong E. Kim (Purdue), "Cross Section for Cold Deuterium-Deuterium Fusion", *Fusion Technology*, Vol 17, No 3, May 1990, pp 507-508, 8 refs.

ABSTRACT

Conventional estimates of cold deuterium-deuterium (D-D) fusion rate and branching ratio may not be reliable, since they are based on an extrapolation of the reaction cross sections at higher energies (usually > than 4keV) to lower energies where no direct measurements exist. Recent results of indirect measurements of the cross section indicate that the extrapolation method may not be valid at low energies. Direct measurements of the D-D fusion reaction cross section at low energies are suggested.

COMMENTS

Kim points out that the Beuhler et al results (experiments on impact fusion) can be regarded as the first indirect measurement of the expected cross section at E = about 0.15 keV. In addition, the experimental results of Beuhler is a test that invalidates the conventional extrapolation method used to support equal branching ratios for d+d fusion.

NOTE: Previous issues of Fusion Facts provide summaries of other papers by Kim dealing with fusion probabilities. In the April 1990 issue, page 12, three papers from Purdue (Kim et al) are summarized.

SUGGESTIONS FOR THE MEDIA

Martin Fleischmann and Stanley Pons, "Press should separate facts, opinion", *Deseret News*, March 28, 1990. As an anniversary gift to the media Fleischmann and Pons make the following suggestions (especially to *Nature*):

1. Clearly separate facts and editorial opinions.

2. Presentation of facts should be impartial.

3. Observations (experimental facts) are more valid than theories.

4. Innuendo should be avoided. In its worst form it becomes scurrilous or vituperative.

5. Committee reports (science by consensus?) should be treated as editorials and not science facts.

6. Avoid labels. Examples are the premier Journal of Electroanalytical Chemistry being called "a minor scientific journal" and Professor Nathan Lewis' strong comments being labeled as "articulate and forthright".

7. Judge scientists by their words (Citation Index) and not by their acceptance or rejection of cold fusion.

NOTE: This editor can be criticized for not being impartial. Our reporting favors the reality of cold fusion -- but to us that is justified scientific acumen or at least justified optimism.

EXCESS HEAT AT OAK RIDGE
(Courtesy of Dr. Charles D. Scott)

Charles D. Scott, John E. Mrochek, Timothy C. Scott, Gordon E. Michaels, Eugene Newman, and Milica Petek (Chem Tech Div, ORNL), "Measurement of Excess Heat and Apparent Coincident Increases in the Neutron and Gamma-Ray Count Rates During the Electrolysis of Heavy Water", Accepted for publication by *Fusion Technology*, April 17, 1990, 24 manuscript pages and 12 figures.

ABSTRACT

Excess heat and apparent increases in the neutron and gamma-ray count rates have been observed in a series of tests performed at Oak Ridge National Laboratory to study the electrolysis of heavy water in the presence of palladium cathodes. For these tests, LiOD concentration of 0.1 to 1 Normal in D_2O was used in an insulated glass electrochemical cell in which the temperature was controlled and heat was removed by flowing water in a cooling jacket. Results of two of the tests, one of which lasted for over 1900 hours, are reported here. In the latter test, an internal D_2-O_2 recombiner was incorporated into the cell to give a closed system without off-gas.

Excess power, usually in the range of 5% to 10%, was detected for periods of many hours. Some of these events were initiated and could be extended by system perturbations. On three separate occasions, the mean neutron count rate exceeded the background by statistically significant values; one of these was apparently coincident with an extended period of excess heat generation. Increases in the gamma-ray count rates were apparently also coincident with two of the periods of excess neutrons.

COMMENTS

The Pd cathode was made from 99.9% Pd that had been cast under argon and then swaged to about 0.55 cm. in diameter and 8 cm. long. A Pt anode and Pt connected wires were used in the cell structure. Interelectrode spacing was about 0.3 to 0.5 cm. The open cell was run for 540 hours with successive increases in the cathode current density (up to 600 mA/mc^2). At about 540 hours excess heat was measured for the first time. During the next 300 hours the power excesses ranged as high as 11% (above the experimental error of about 3%). When excess power faded, perturbations to the electrolyte concentration or temperature seemed to be effective in restoring excess power.

With the closed cell experiments excess heat was noted after about 740 hours. Thereafter there were two major periods of spontaneous excess power, each of which lasted for several hours. These were relatively modest excesses with maximum values of about 6% but well above the calculated experimental error of about 1% to 2%. A heat loss through the top of the cell of an estimated 1% to 3% was not calculated, therefore, excess heat measured was conservative.

Exchanging the D_20-LiOD to use of H_2O-LiOH caused the excess energy to gradually drop to near zero balance over a period of 100 hours. [This experimental result can be cited as a strong indication that the nuclear reactions producing excess heat are bulk reactions. Ed.]

Decreasing the electrolyte temperature appeared to be the best method to perturb the system for renewed levels of excess heat to be generated. The authors state, "The several periods of excess heat were unequivocal and could

not be explained by experimental inaccuracies or artifacts. Analysis of the electrolyte for tritium indicated no increases within the accuracy of 200Bq/l.

ALKALI HYDRIDES
(Courtesy of Dr. Samuel Faile)

Jose Luis Martis (U/Minn), "Equations of State of Alkali Hydrides at High Pressures", *Physical Review B*, Vol 41, No 11, April 15, 1990, pp 7883-7886, 20 refs.

ABSTRACT

The equations of state of the alkali hydrides LiH, NaH, and KH are calculated as a function of pressure for the B1(NaCl) and B2(CsCl) structures using the pseudopotential and local-density approximations. Contributions of the lattice vibrations to the free energy are treated in the quasiharmonic approximation. The results are in good agreement with experiment, in particular when the vibrational effects are included.

CONCLUSIONS

The calculations of the isothermal equation of state of the alkali hydrides show that the inclusion of the zero-point-motion effect in the quasiharmonic approximation has small but not negligible effects, which improve the agreement of the calculations with experiment. The transition pressures and volume changes associated with the B1 to B2 structural phase transition are well described by the ab initio calculations.

COMMENTS

This paper may have some relevance to cold fusion especially as the data may be similar to understanding of deuterides.

LIVERMORE AND SANDIA HYDRIDES
(Courtesy of Dr. Samuel Faile)

M.S. Costantino, J.F. Lakner (both of Livermore), and R. Bastasz (Sandia), "Synthesis of Monolithic Uranium Hydride and Uranium Deuteride", *Journal of the Less-Common Metals*, Vol 159 (1990), pp 97-108, 14 refs.

SUMMARY

We report the synthesis of monolithic uranium hydride and uranium deuteride. In our procedure, we grow the UH_x (UD_x) crystals from the melt at temperatures above 1065 deg C under 125 Mpa hydrogen (deuterium) pressure. We then quench to room temperature at dT/dt < 10 deg C per min at high pressure to allow the stoichiometry to come to UH_3. UH_3 synthesized using this procedure is 100 percent dense, with dimensions of up to 5 mm x 5 mm x 10 mm. X-Ray and Auger electron spectroscopy indicate β-UH^3 with essentially no impurities.

CONCLUSIONS

Monolithic uranium hydride with full stoichiometry, UH_3, can be synthesized by growing the solid UH_{3-x} from the melt under high hydrogen pressure. This procedure avoids the large volume strains, and consequent internal stresses, resulting from converting elemental uranium to UH_{3-x} in the solid. The UH_{3-x} stoichiometry at the melting curve at P approx + 125 MPa and T approx = 1065 deg C is brought to the full UH_3 by cooling to room temperature at about 10 deg C per min under high hydrogen pressure.

COMMENTS

This procedure may be useful in the pre-preparation of deuterides for cold fusion experiments. Ed.

UTAHNS RALLY HELP FOR FUSION

Tim Fitzpatrick, "Utahns Rally Help for Home-Grown Cold Fusion", *The Salt Lake Tribune,* March 31, 1990, p B-1.

Utah Power and Light, the local electrical utility, donates $50,000 to the National Cold Fusion Institute to further the research in cold fusion. In addition, an anonymous donor provided an undisclosed amount (thought to be about $500,000) to the Institute. Previously the Utah State Legislature had authorized $5 million to be spent on legal and research work on cold fusion.

FUSION CLAIMS REITERATED

Jerry Bishop, "'Cold Fusion' Chemists Reiterate Claim; Other Scientists Report Similar Results", *Wall Street Journal*, p B4, March 30, 1990.

With a Salt Lake City date line, Mr. Bishop reports on the early part of the First Annual Conference on Cold Fusion. Pons and Fleischmann reiterate their claims of the discovery of cold fusion and are joined by scientists from other institutions. Bishop reports on the hallway controversy caused by the timely printing of an article in *Nature* together with a scathing editorial that labeled cold fusion as "discreditable to the scientific community as a whole". Pons presented his new paper (to be published in the Journal of Fusion Technology) in which he shows that some cold fusion cells produced 17 to 40 times as much energy as was being input to the cell. The excess

energy produced, Pons is quoted as saying, "far exceeds the heat which could be generated by any conceivable chemical process."

COLD FUSION - COLD SHOULDER

Jerry Bishop, "'Cold Fusion' Gets Cold Shoulder From Many a Year After Findings", *Wall Street Journal*, p B4, April 3, 1990.

While in Salt Lake City covering the First Annual Conference on Cold Fusion, Jerry Bishop reports that skeptics find the latest reports "interesting" but are still looking for convincing evidence of nuclear reactions. Reports from over 40 different laboratories indicate a small but growing number of scientists are finding cold fusion evidence. Scientists differ on whether the observed results come from surface or bulk reactions within the palladium cathode. Researcher concede that there will be many skeptics until a recipe can be provided that will work every time.

COLD FUSION HEATS EARTH

Jerry Bishop, "'Cold Fusion' May Keep Earth's Core Molten", *Wall Street Journal,* April 17, 1990, p B-1.

Physicist Stephen E. Jones and geologist Paul Palmer at Brigham Young University in Provo, Utah suggest that cold fusion nuclear reactions may be the source of heat for the earth's interior. Professors Jones and Palmer are working on the measurement of volcanic gases to determine if tritium or other nuclear byproducts are being produced and vented into the earth's atmosphere from active volcanoes. Their work is being funded by DoE.

THE COLD-FUSION FAITHFUL
(Courtesy of Dr. Robert W. Bass)

Thomas Maugh II, "Cold-Fusion Faithful Still Fan the Flames of Research", *Los Angeles Times,* April 9, 1990.

Maugh reports on The First Annual Conference on Cold Fusion and surmises that reports of the death of cold fusion may be premature. In contrast Dr. Robert Parks, President of the American Physical Society termed the meeting as a "seance of true believers."

The department of energy laboratories have added credibility to cold fusion, however, most observers outside the field are still not ready to accept the evidence. Problems in cold fusion still plague this new science and must be resolved before wide-spread acceptance can be expected. "Meanwhile", Maugh reports, "the specter of a chemist who wasn't present at this meeting hovered in the wings. Glen Schoessow of the University of Florida in Gainesville has told colleagues and some members of the news media that he is able to turn cold fusion on and off at will in his laboratory... Schoessow says he had been forbidden to talk about his results or to come to the meeting by his patent attorneys."

HEAVY-ION FUSION
(Courtesy of Dr. Samuel Faile)

Staff, "Future Fusion", *Science Digest*, April/May 1990, pp 77-78.

This brief article reports that a commercial generator (that may have to be more than three miles long) could possibly produce commercial power. The article includes the following: "Cold fusion generated a lot of excitement last year, but unfortunately, it may never generate anything else. **A more promising approach to fusion power is heavy-ion fusion, in which a particle accelerator shoots lead or other massive, charged particles into capsules of hydrogen, imploding the hydrogen and releasing energy.**

NANOPHASE MATERIALS
(Courtesy of Dr. Samuel Faile)

Russell Ruthen, "Go with the Grain", *Scientific American*, May 1990, pp 29-30.

Small crystals with grain size only a few billionths of an inch in size are used to make "nanophase" materials. The first such materials were made in Germany in 1986. Argonne National Laboratory scientists have found that nanophase materials can be three to five times harder than similar coarse-grained materials. In addition, it has been found that gas diffuses through nanophase materials at rates thousands of times faster than through course-grained materials. [See also article on superdiffusion by Koike under NEWS FROM ABROAD. Ed.]

PURSUING PATHOLOGICAL SCIENCE
(Courtesy of David Mitchell)

Douglas R. O. Morrison, "First Annual Cold Fusion Conference", *Cold Fusion News* No. 22, Computer net: MORRISON@VXPRIS.decnet.cern.CH, 13-17 April 1990.

SUMMARY

1. Impressions of the First Annual Cold Fusion Conference.

2. Paper by Pons and Fleischmann.
3. New Results from the Experiment of Salamon et al in Pons's Lab.
4. National Laboratories.
5. Japan.
6. India.
7. Solar Neutrinos.
8. Oppenheimer-Phillips mechanism.
9. Selling a Patent.

EDITOR'S COMMENTS

Dr. Morrison was in attendance at the First Annual Cold Fusion Conference and was eager to ask questions after many of the papers were presented. Morrison is noted for two things: his extensive interest in pathological science, and his achievement for aiding the CERN countries to NOT expend time and effort in pursuing cold fusion research. Morrison believes that 90% of the work on cold fusion has been negative and that those negative results should be presented and fully discussed. It is the judgement of this editor that in nearly all cases, the negative results were the result of the lack of proper rod preparation. [See Dennis Cravens, "A Solid-state Fusion Review", *Fusion Facts*, March 1990.]

Morrison's impressions are those of a confirmed skeptic, however, he has just enough positive statements to be able to later claim to have been a supporter of cold fusion. Most of the paper is devoted to elaborations of negative comments. In the midst of some 40 papers, nearly all of which were positive or presenting theory, Morrison failed to find anything to reduce his level of belief that cold fusion is pathological science.

Under the heading, JAPAN, Morrison reports: "In February [1990] there was a meeting of Japanese interested in Cold Fusion and some thirty papers were presented. Of these about ten were theoretical, ten found no effect and ten found positive effects." [In another section of this paper Morrison cites the world's results in cold fusion experiments as being 90% negative.]

Morrison comments on the Oppenheimer-Phillips Mechanism and cites S.E. Koonin and M. Mkerjee (Caltech report MAP-129) "who find the effect is negligible, changing the rate less than 1%." Morrison does not comment on the three Purdue papers by Kim and others who have been dealing extensively with the probability of fusion in metal lattices at low energy levels and whose findings are considerably different from Koonin and Mkerjee. [See also Danos paper in this section. Ed.]

Note for historians: Morrison's computer network series of papers on cold fusion will be of historical interest as it shows how a skeptical view by a dedicated scientist, but well circulated, has kept several European nations from exercising their scientific curiosity.

GLEANINGS FROM THE COMPUTER NETS
(Courtesy Dr. Sam Faile - accessing ECHO net)

Alan Lovejoy, 18 April 1990, under sci.physics.fusion Discussion concerns reproducibility, its value and need to satisfy cold fusion critics. Following are excerpts:

"When someone is able to specify the experiment in such a way that just about any competent experimenter can reproduce The Effect with some non-zero probability of success for each attempt -- and that probability does not vary wildly among different experimenters -- THEN The Effect will be considered reproducible."

Charles Poirier, 17 April 1990, under Sci.Physics.Fusion Poirier states some ideas (wild and otherwise):

"Has any successful CF run been carried out inside a Faraday cage? ... What a howl it turns out that biased, deuterated Pd is simply a good absorber of radio station KROK or whatever."
"...Stirring might be an important experimental variation.
"...Stirring would be one way of modulating bubble effects..."
"...Someone please point an imaging infrared scanner at an active cell? This will show exactly where heat is coming from; whether it is point sources within the metal, or uniform, or at bubble boundaries, ... "
"...Isn't anyone's curiosity aroused about bombardment of lithium with muons? Does it fuse, or perhaps release other weird species?"
"...has anyone tried putting lithium into the palladium electrode directly, by metallurgical means?"

LETTERS FROM READERS

VANADIUM-ZIRCONIUM BUTTONS
(From Dr. Samuel Faile, Cincinnati)

I have sent the V_2Zr rod to be machined by wire EDM [Electrical Discharge Machining] to obtain 3/4 inch diameter by 1/8 inch thick coin size cathodes. Hopefully, the one mil surface layer of remelted material can be removed by an emery cloth.

Faile also wrote: "Dr. Vinod Sikka at Oak Ridge suggests comparing an annealed wafer to an unannealed one in the cold fusion tests."

[Vanadium-Zirconium disks can be obtained from Dr. Samuel P. Faile, P. O. Box 62579, Cincinnati, Ohio 45262, Phone 513/563-4953]

IMPLANTING PALLADIUM ISOTOPE

Dr. Samuel Faile also suggests: "Some tantalizing reports of an isotope shift from Pd-105 to Pd-106. Suggestion: Little plugs of nearly pure Pd-105 could be inserted and laser welded into the cathode structure. Then these plugs of palladium could be monitored for possible enhanced cold-fusion activity. Pd-105 is available from Oak Ridge for about $28 for a milligram."

TRY SUPERHEAVY WATER

Dr. Samuel Faile suggests: "Try the substitution of T_2O for D_2O in an operating cell that produces excess heat. This experiment could provide additional clues if there is a change in the amount of excess heat and a change in the reaction products and the isotope shifts."

TRY NANOPHASE PALLADIUM

Dr. Samuel Faile suggests: "The deuterium loading time has been estimated for some types of electrolytic cells. [and can be a substantial number of hours] ... Try a nanophase palladium cathode and see if one can obtain excess heat much sooner for a matrix that loads up orders of magnitude faster. Argonne National Laboratory has been making nanophase materials." [A nanophase material is made from very small granules of the material. Ed.]

LITHIUM NUCLEAR REACTION

Jerry Drexler in an April 20, 1990 letter addressed to "Participants - First Annual Conference on Cold Fusion" states:

"I just received Professor J. O'M Bockris' excellent paper entitled, 'A Review of the Investigations of the Fleischmann-Pons Phenomena'. I wish to thank him for this extremely valuable and timely document on current theories and experimental results.
"One omission from that paper is the lithium 6 - deuterium reaction suggested to explain 'cold fusion' by Professor Robert T. Bush, of the Physics Department of California State Polytechnic University, in his presentation at the conference and in his December 1989 paper. Associate Professor of Natural Sciences, Joel Brind, at the Baruch College, City University of New York, also suggested this same reaction to explain 'cold fusion' in *Science News*, March 17, 1990.

"My two PCT [Patent Convention Treaty] patent applications on several 'co-ld' fusion energy cell design configurations ... are also based upon this same lithium 6 - deuterium reaction.

NOTE: Jerry Drexler is the founder of Drexler Technology Corporation and a specialist in photolithography as used in the development of integrated circuits and in the LaserCard. Jerry suggests that 'co-ld' fusion might be interpreted as "with Li & D".

NOTE: The reaction is $^6Li + D \rightarrow 2\ ^4He + 22.4$ MeV. This reaction is now believed by some experimenters to be a palladium surface reaction. It is suggested by some that both the lithium reaction and the deuterium fusion reaction (as a bulk reaction) occur with the lithium - heavy water - palladium system. Stay tuned for the latest developments. Ed.

* *

C. FUSION NEWS FROM ABROAD

ARGENTINA - COLD FUSION UNDERWATER
(Courtesy of Dr. Samuel Faile)

J.R. Granada, R.E. Mayer, P.C. Florido, V.H. Gillette, and S.E. Gomez (U. Nacional de Cuyo, Rio Negro, Argentina), "Neutron Measurements on Electrolytic Cells (Pd-D2O) Performed under very low Background Conditions". Accepted for publication in *Journal of Nuclear Science & Technology.* Paper dated December 1989. 4 refs, 2 tables, in English.

CONCLUSIONS

With the use of a high efficiency neutron detection system in combination with a procedure involving the pulsing of the electrolytic current, we have performed measurements on electrolytic cells containing deuterated Palladium cathodes. The unique feature of these experiments is that they were performed in a submarine vessel deep under the sea surface, thus attaining very low background conditions which represent a reduction by a factor of 70 respect to our laboratory values. Many similar runs were performed on different cells containing D_2O and one test cell with H_2O. The results show that individual count rates measured from deuterated cathodes are separated by three standard deviations from the background level. The combined 'signal' count rate turns out to be separated by six standards deviations from the count rate due to the background.

The present results represent a clear evidence of neutron production in electrolytic cells containing deuterated Palladium cathodes. Although the observed effect is of very low intensity. It is by all means of greatest interest from the point of view of fundamental research at this stage.

COMMENTS

The above experiments used electrolytic cell configurations that are described in the following paper:

ARGENTINA - PULSED ELECTROLYTIC CELLS
(Courtesy of Dr. Samuel Faile)

J.R. Granada, R.E. Mayer, G. Guido, P.C. Florido, A. Larreteguy, V.H. Gillette, N.E. Patino, J. Converti, and S.E. Gomez (U. Nacional de Cuyo, Rio Negro, Argentina), "Thermal Neutron Measurements on Electrolytic Cells With Deuterated Palladium Cathodes Subjected to a Pulsed Current." Accepted for publication in *Journal of Nuclear Science & Technology*. 9 refs, 9 figures, in English.

ABSTRACT

The present work describes the design of a high efficiency thermal neutron detection system, and the measurements performed with it on electrolytic cells containing LiH [sic] dissolved in D_2O with Palladium cathodes. A procedure involving the use of a non-stationary (pulsed) current through the cell caused a correlated neutron production to be observed in a repeatable manner. These patterns are strongly dependent on the previous charging history of the cathodes. The technique employed seems to be very useful as a research tool for a systematic study of the different variables governing the phenomenon.

CONCLUSIONS

We have observed in our experiments a clear correlation between neutron production response and the pulsing of the electrolytic current through deuterated Pd cathodes. Even though these results cannot be conclusive per se to settle the issue of the cold fusion phenomena, they constitute a piece of experimental evidence which lends support to the existence of such processes. The measuring methodology introduced has proved to be successful in the attainment of the basic goals for which it was devised, thus rendering an adequate tool for the systematic study of the different variables which may govern the proposed cold fusion phenomena. Further experimental work along these lines is in progress at our laboratory.

COMMENTS

The experimental cell does not conform to the usual cylindrical symmetry of the typical Fleischmann-Pons cell in that the cathode (regardless of shape) is suspended among "anode consisted of Pt foils (6N) of 20 x 45 mm^2 placed at both sides of a Pd cathode." The electrochemical cell is then housed within an array of neutron measuring tubes inside a borated paraffin structure about 1 meter in diameter.

NEWS (AND ABUSE) FROM ENGLAND

David Lindley (American Office), "The embarrassment of cold fusion", *Nature*, Vol 344, pp 375, 29 March 1990.

The sub-heading tells it all: "The variable and transient claims of experimental evidence for cold fusion made a moving target which attracted **too much enthusiasm and too little derision.**" That this headline (and other statements made in the article) should appear in a publication that reports on science is unwarranted. [See comments made by Fleischmann and Pons reported under News from the U.S. Ed.]

Lindley makes the following false statement: "During the past year, the original claims of Pons and Fleischmann have diminished; the experimental evidence has been subtracted from not added to." To make such a statement, Lindley would have to be living in a world shielded from scientific reality. It is interesting that such a misleading statement was published on the eve of the First Annual Conference on Cold Fusion. [See the many additional evidences for cold fusion that were reported from the conference in the April 1990 issue of *Fusion Facts*. Ed.]

NEWS FROM GERMANY

THEORY PAPER

M. Hietschold (Tech. U., Karl-Marx Stadt), "Electric field control for cold nuclear fusion? - a suggestion", *Wiss, Z. Tech. Univ. Karl-Marx-Stadt,* 1989, Vol 31, No 4, pp 635-636, in Engl.

ABSTRACT from Chem Abstract

In cold fusion possibly the deuterons in the Pd electrode might be trapped at the surface in interstitial positions in the lattice. It is probably the high density of the deuterons and the influence of locally strong internal electric fields which enables the high energy transfer rate to a single deuteron sufficient to produce fusion.

NEWS FROM INDIA
(Courtesy Ramtanu Maitra, Editor of Fusion Asia)

Ramtanu Maitra, "A New Problem for Cold Fusion Non-Believers", *Fusion Asia*, Vol 6, No 2, 1989, pp 12.

Maitra reviews the reports from Texas A&M on the careful measurements of tritium production using an electrochemical fusion cell.

Ramtanu Maitra, "Fusion Information Center Formed to Monitor Cold Fusion Activities", *Fusion Asia*, Vol 6, No 2, 1989, p 13. This report tells of the establishment and operation of the private corporation and its publication of Fusion Facts. [Thanks. Ed.]

Kiyoshi Yazawa, "Cold Fusion in Japan: Excitement and Success",*Fusion Asia*, Vol 6, No 2, 1989, p 14.

Yazawa reports briefly on the work at the Universities of Tohoku, Hokkaido, Aoyama-Gakuin, Tokyo U. of Ag and Tech, and the Japan Atomic Energy Research Institute. Scientists from these institutions were involved in a July 31, 1989 symposium in Japan on cold fusion. Akito Takahaski at the U. of Osaka used palladium in a heavy water electrolyte using lithium sulfate. Some neutron production was observed.

NEWS FROM ITALY

NEUTRONS, TRITIUM, AND HEAT

D. Gozzi, P.L. Cignini, L. Petrucci, M. Tomellini, G. DeMaria, S. Frullani, F. Garibaldi, F. Ghio, M. Jodice (U. Roma), "Evidences for Associated Heat Generation and Nuclear Products Release in Palladium Heavy-Water Electrolysis", *Il Nuovo Cimento,* Gennaio 1990, Vol 103A, No 1, pp 143-154, 14 ref. In English.

ABSTRACT

In a galvanostatic experiment of charging D in a Pd cathode, nuclear and thermal effects were measured. A sintered Pd parallelepiped was used. After six days of electrolysis at 200 mA/sq cm, a simultaneous emission of neutrons, tritium excess in the electrolyte, and rapid temperature rise were noted. The four minute event released 7.2×10^5 neutrons; about 2.14×10^{11} tritium atoms, and the cathode reached 150 deg C. The heat energy (176 Joules)is about 1000 times the heat derived from neutron and tritium reactions. The electrode characteristics after operating are reported.

COMMENTS

A parallelepiped cathode of Pd was made from Pd sponge powder sintered in vacuum at 900 deg C for 10 hours. The anode was a Pt gauze cylinder. Electrolyte was D_2O with 0.1M LiOD in an open cell configuration. Neutrons and gamma rays were monitored and tritium measured. A glass-protected S-type thermocouple was epoxied to the end of the Pd and sealed from the cell environment with a glass tube. Controls were used to switch off the applied current if the electrode temperature exceeded 80 deg C. $200 mA/cm^2$ current was applied. After 150 hours a nuclear and thermal effect was simultaneously recorded. During a short interval neutrons counts were at least 180 times background. Current was turned off automatically when the temperature reached 80 deg C. The temperature rise continued to an estimated 150 deg C and then dropped asymptotically.

The D/Pd ratio achieved was measured at 0.706 [which is deemed to be on the low side for the generation of excess heat. Ed.] Lithium atoms were found in the outer surface of the Pd cathode and deemed to be a result of solid-state diffusion. Any nuclear role played by Li is unknown.

NEUTRON EMISSION THEORY

S.E. Segre, S. Atzeni, S. Briguglio, F. Romanelli (Univ. Roma), "A mechanism for neutron emission from deuterium trapped in metals", *Europhys. Letters*, 1990, Vol 11, No 3, pp 201-206, in Engl.

ABSTRACT from Chem Abstracts

A mechanism for neutron emission from deuterated metals is proposed, which is based on some known phenomena, concerning hydrogen participation in supersaturated metals. Transient electric fields are assumed to produce energetic deuterons and hence neutrons from $D(d,n)^3He$ reactions. The mechanism predicts neutron yields compatible with those reported in some of the experiments and implies a degree of experimental non-reproducibility.

NEWS FROM JAPAN

SPECIAL SESSION FOR COLD FUSION JAPANESE ATOMIC ENERGY SOCIETY (April 2-4, 1990).
(Courtesy of Prof. Takaaki Matsumoto)

About 130 specialists attended this cold fusion session and reported the results from 13 studies. Six of the experimenters obtained positive results. A summary of the most significant papers are shown below:

JAPAN: HYDROGEN DISTRIBUTION

M. Tamaki, et al (Nagoya Univ), have measured the hydrogen distribution in Pd by the neutron radiography method. Using the large scattering cross section of hydrogen, the axial and radial distributions of hydrogen were measured. Clear results were obtained that the hydrogen was stored in grain boundaries and easily moved by applied electrical voltage.

JAPAN: GAS-LOADED TITANIUM

Y. Ozawa et al (Hitachi Co. Ltd.) reported on experiments with the TiD_2 gas phase system. Neutron measurements were made with both ^3He and BF_3 counters. The deuterium under pressure of 20 to 50 atmospheres was used to load the Ti. They obtained meaningful results of neutron emissions at about -20 C. The counts exceeded the background by more than 3 sigma and corresponds to the neutron production rate of 1 to 10 neutrons per second. The author's results do not resemble the continuous neutron emission as observed by the Frascati group but does correspond to the neutron bursts observed by the LANL group.

JAPAN: PROGRESS USING THE NATTOH MODEL

NOTE: The NATTOH model assumes that several deuterons in a metal form an extremely small cluster, called Nattoh.

T. Matsumoto (Hokkaido Univ.) presented progress in using the NATTOH model [1].

Energy Distribution of Fusion Products

It is important to know what types of fusion reactions take place in metal, in order to understand mechanisms of cold fusion. The direct and important information is the energy distribution of the fusion products. An analysis has been made by the NATTOH model [2]. Two important results have been obtained. First, is that the hydrogen-catalyzed fusion reaction concept can explain the energy distribution and that the scattered hydrogen atoms from the fusion reaction have enough energy to lead to additional reactions. Second, is that the model predicts the occurrence of new particles from cold fusion.

Fusion Chain Reactions

The NATTOH model can be used to illustrate a chain reaction in hydrogen isotopes [3] (similar to the neutron's role in chain reactions in fission reactors). Equations for the behavior of free hydrogen (deuterium) and for ions or atoms of H and D trapped in the grain boundaries have been derived from the model. For the static case, the critical equation has been shown with the result that the power is proportional to the volume of the fuel rod. The time behavior for the startup and shutdown by the flow (leakage) of hydrogen atoms is shown. It is also shown that the cold fusion reactor is intrinsically safe because the hydrogen (deuterium) atoms themselves are the fuel.
Prediction of a New Particle "Iton".

In the analysis of the energy distribution of the cold fusion products, it should be assumed that about 20 MeV of excess energy is taken away by one or more new particles. This particle is called an "iton" which means 'a string' in connection with NATTOH. The new particle emission has also been suggested as a nuclear byproduct when cold fusion occurs with ordinary water [4].

Observation of a New Particle "Itons".

An electrolysis experiment [5] with heavy water has been performed in order to recognize the emission of the new particle "itons". Nuclear films have been successfully used to record tracks which are caused by the decay of the "itons". It is shown that the "itons" probably consist of an electron, a positron, and a neutrino.

REFERENCES:

[1] Takaaki Matsumoto, "'NATTOH' model for cold fusion", *Fusion Technology*, Vol 16, p 532, (1989).

[2] Takaaki Matsumoto, "Prediction of new particle emitted by cold fusion", submitted Feb 1990 to *Fusion Technology*.

[3] Takaaki Matsumoto, "Theory for cold fusion reactor", submitted to *Fusion Technology*, February 1990.

[4] Takaaki Matsumoto, "Cold fusion observed with ordinary water", *Fusion Technology*, Vol 17, March 1990. [See summary of this article immediately below.]

[5] Takaaki Matsumoto, "Observation of new particles emitted by cold fusion", submitted to *Fusion echnology*, March 1990.

JAPAN: COLD FUSION IN ORDINARY WATER.

Takaaki Matsumoto, "Cold fusion observed with ordinary water", *Fusion Technology*, Vol 17, pp 490-1, 3 pgs, 4 refs, March 1990.

ABSTRACT

A cold fusion electrolysis experiment using ordinary water is described. A Ge(Li) detector is used to observe signals up to about 130 keV; these signals show the occurrence of fusion reactions in ordinary water. The mechanism for the emission of radiation is discussed by the Nattoh model.

COMMENTS

The article describes experiments using a typical cold fusion electrochemical cell with Pd cathode and a Pt

anode. The electrolyte used was water plus 3% sodium chloride. Pd rod (50 mm dia x 50 mm long) was maintained in a vacuum at about 800 deg C for 10 hours before use. Fusion events were measured with an EG&G Ge(Li) detector. Both detector and cell were shielded with about 15 cm. of lead. One item we would like to see in the paper would be a chart showing the amount of radiation inside the lead shielding without the cell in operation. The results between background and cell output are not dramatically different but are significantly different. In the summary, the author notes that it is not necessarily adequate to use ordinary water as a standard cell to compare against another type of fusion cell. The author suggests that the factual existence of fusion in ordinary water can possibly be developed into systems that produce power from seawater.

JAPAN: SUPERDIFFUSION OF H
(Courtesy of Dr. Sam Faile)

Shigetochi Koike, Akinori Kojima, Makoto Kano, Manabu Otake, Hideo Kojima, and Taira Suzuki (Sci U of Tokyo), "On the Superdiffusion of Hydrogen in V_a-Metals", *Journal of the Physical Society of Japan*, Vol 59, No. 2, Feb 1990, pp 584-595, 27 refs, in English.

ABSTRACT

Experimental procedures for the determination of superdiffusion coefficients of hydrogen in V_a-Metals (V, Nb, Ta) under external tensile stress parallel to <111> are described in detail. Results are analyzed in the light of the lattice activated tunneling theory. The activation energy E_a and the tunneling matrix element |J| are obtained experimentally as follows:

E_a(MeV): 21 for V, 15 for Nb, 12 for Ta, and

{J}(MeV): 0.44 for V, 0.085 for Nb, 0.065 for Ta.
The superdiffusion mechanism of hydrogen in these metals is theoretically discussed.

COMMENTS

An anomalous enhancement in the diffusion rate for H and D has been found in vanadium and tantalum crystals under tensile stress. Diffusion rates up to 100 times normal have been observed. This paper reports a new work on superdiffusion of H in niobium crystals and discusses the results. It was experimentally shown that the superdiffusion is achieved at low stress levels as the temperature of the metal is raised. Figures shown data from 203 K to 238 K.

JAPAN: DESTRUCTION OF SUPERDIFFUSIVITY
(Courtesy of Dr. Sam Faile)

Taira Suzuki, Shigetoshi Koike, and Makotot Kano (Science U. of Tokyo), "Destruction of Superdiffusivity of Hydrogen in Vanadium by the Applied Electric Field, *Journal of the Physical Society of Japan*, Vol 59, No 2, Feb. 1990, pp 596-600, 7 refs, in Engl.

ABSTRACT

Superdiffusivities of hydrogen in vanadium and niobium decrease by one order of magnitude by the application of electric field. Analyses of the experimental data have been carried out on the basis of the Kondo and Yamada et al. theory. The magnitude of the interaction between proton and conduction electrons in vanadium designated by K is estimated to be 0.24. This is compared with K = 0.3 ofM^+ in copper estimated by Kondo. Calculation of the diffusivity as a function of the strength of applied electric field has been carried out and shown to be in good agreement with experiment.

CONCLUSIONS

Diffusivity of hydrogen in vanadium and niobium in the superdiffusion state is remarkably influenced by the application of electric field. This is considered due to the increase of the strength of interaction of proton with conduction electrons. The tunneling probability is reduced on this account. Applying the theories given by Kondo and Yamada et al., we successfully carried out the calculation of the diffusivity as a function of the strength of applied electric field. It supports, therefore, that hydrogen in the super-diffusion state in those metals under the external electric field moves by the hopping mechanism subjected to the influence of scattering of conduction electrons.

COMMENTS

The diffusion coefficients for hydrogen in vanadium in the superdiffusion state varies from about 10^{-7} to 10^{-8} (m^2/s) as a function of current of the order of 100 to 500 amperes per cm^2. The diffusivity decreases by about ten when the current density is increased. For cold fusion cathodes the nominal current densities range from 60 mA/cm^2 to 5 A/cm^2. However, future fusion cells may work at higher amperage. This effect may be of some interest. It would be of interest to measure the diffusivity in Pd as a function of the applied electric field. Ed.

JAPAN: INTENSE COLD FUSION

Y. Arata, Y.C. Zhang (Welding Res Inst, Osaka U.), "Achievement of intense 'cold' fusion reaction", *Proc. Japan Acad. Ser. B*, 1990 Vol 66, No 1, pgs 1-6.

ABSTRACT from Chem Abstracts

A Pd cathode of large size was activated by repeating intensive absorption and explosive exhaust of D compulsively due to the powerful on-off effect to induce intense mobility and a huge inner pressure of D within the Pd cathode. This characteristic played a role in achieving cold fusion. A considerable number of neutrons far beyond the background level, sometimes reaching more than 10^8 neutrons per second, were detected. The phenomena were observed ten times in one month, and the period was 30 minutes for the shortest event and 40 hours for the longest. The total number of neutrons generated was estimated to be 10^{13} for 40 hours at the maximum and it would be difficult to consider other than nuclear fusion by D-D reaction. The large amount of excess heat produced during electrolysis was not due to unobserved nuclear fusion proposed by M. Fleischmann et al (1989), but due to reaction heat produced by the intense absorption and explosive exhaust of the D into and out of the Pd. The Pd cathodes used by all other researchers were far smaller than the present one. This is likely the reason why the new on-off effect phenomenon and the generation of intense cold fusion was not found so far.

NOTE: Fusion Facts is trying to get a copy of this paper. More details of the electrolyte and cell pressures would be of considerable interest. If any readers have a copy, please fax a copy to us. 801/272-3344 Ed.

NEWS FROM PORTUGAL

N. Shohoji (Lab. Nac. Eng. Technol, Lisbon), "Unique features of hydrogen in palladium metal lattice: hints for discussing the possible occurrence of cold nuclear fusion.", *Journal Material Science Letters,* 1990, Vol 9, No 2, pp 231-232, in Engl.

ABSTRACT from Chem Abstracts

The fusion of D. in Pd was analyzed in terms of hysteresis behavior, retention of crystal structure upon hydride formation, and electrode metal holding its solid shape during cathodization without disintegration. Other possible candidate metals for electrodes are nickel, cerium, and actinium.

NEWS FROM SWEDEN

(Courtesy of Geo. Miley, Ed., Fusion Technology)

Magnus Jandel (Manne Siegbahn Institute of Physics, Stockholm), "Cold Fusion in a Confining Phase of Quantum Electrodynamics", *Fusion Technology*, Vol 17, No 3, May 1990, pp 493-499, 39 refs.

ABSTRACT

Both cold fusion and the recently observed tightly correlated electron-positron pairs from heavy-ion collisions point to new physics in the energy range of 1 MeV. The possibility of a confining phase of quantum electrodynamics is considered. We speculate that a small domain of the new phase in a deuterium-rich environment could grow by inducing fusion reactions and absorbing the released energy.

COMMENTS

Figure 1 in the article depicts graphically a CQED (confining phase of quantum electrodynamics) with the following description: "Hypothetical CQED phenomena: A metastable CQED domain is filled with thermal electromesons. Deuterons and electrons enter from the surrounding metal deuteride, forming (D-D)* states where the nuclear components rapidly fuse. The dominating fusion product at chemical equilibrium is ^{4}He. Nuclei and neutrons diffuse in the electromeson liquid. Helium atoms can escape from the CQED energy E_2 + 5 MeV transformed to kinetic energy."

The author uses a bag model (citing references): "Neutral composite states in metastable CQED matter are built from charged particles and photons. In a bag model [cites 5 references] description, such states are viewed as bubbles of normal QED vacuum embedded in the new phase." Later the author states: "The finite contribution from the zero-point oscillations of the bagged electromagnetic field is E_Z + 0.093/2L in a situation where normal electromagnetic theory holds outside the bag. In the present case, we have to absorb the divergent parts of the zero-point energy by renormalizing volume-surface- and curvature- dependent bag energies, thus also introducing an uncertainty in the finite part."

The author's final statement is: "A metal-deuterium system with a verified large sustained anomalous power output can be used for a critical test of this model. A typical CQED domain with radius + 6 x 10^{-4} cm weighs 10^{-7} grams. Hence, dissolving the sample in an acid would leave the bare CQED domain at the bottom of the container, where it can be observed as a tiny intensive radiation source."

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D. COLD FUSION POSITION PAPER
By Hal Fox, Revised May 1990
(Previous revision: *Fusion Facts*, August 1989)

BACKGROUND

As announced by Fusion Information Center, Inc. (FIC) in its June 9, 1989 press release: "The discovery of solid-state fusion has been confirmed, there are more than one nuclear reactions occurring, and the process has commercial applications."

The following position paper has been prepared to provide a "given" foundation as a basis for the development of technological impact studies. Most issues of *FUSION FACTS* contain an article that summarizes the impact that the development of fusion energy systems are expected to have on a selected industry.

THE ROLE OF PALLADIUM

Solid-state fusion reactions appear to occur near the surface and within the metal lattice of a palladium electrode immersed in an electrolyte made up of deuterium oxide (heavy water) and the addition of a lithium compound (usually LiOD). Titanium and possibly other metals or a combination of metals will probably support commercial fusion reactions in the future. Currently all successful investigations have used palladium or titanium. Titanium has been successfully used in demonstrations of cold fusion using deuterium gas-loaded metals.

Palladium (symbol Pd) has an atomic number of 46 and an atomic weight of 106.4. Palladium melts at 1551 degrees Centigrade and boils at 3140 degrees Centigrade. The specific gravity is 12.02 and Pd has a valence of 2, 3, or 4. Palladium is the least dense and has the lowest melting point of the platinum group of elements.

The expected abundances of the isotopes of palladium are [1]:

^{102}Pd ----- 0.95%
^{104}Pd ----- 10.97%
^{105}Pd ----- 22.23%
^{106}Pd ----- 27.33%
^{108}Pd ----- 26.71%
^{110}Pd ----- 11.81%

NOTE: These isotopic ratios may change when the Pd is used as a cathode in a working cold fusion cell [2].

OCCURRENCE.

Palladium occurs in the earth's crust at about twice the abundance of platinum. It is found in platinum placers in the Ural Mountains of the U.S.S.R.; in South Africa; to some extent with river platinum placers in the northern portion of South America, Australia, Ethiopia, and North America. The only currently-operated palladium mine in the United States is located in Montana. Palladium is sometimes found with nickel-copper deposits of South Africa and Ontario. Some palladium is produced from the Kennecott copper mine near Salt Lake City, Utah.

PROPERTIES

Palladium has the unusual property of being able to absorb up to 900 times its own volume of hydrogen (or deuterium) at standard temperature and pressure. Hydrogen and deuterium readily diffuse through heated palladium (in the absence of an electric field) and palladium can therefore be used as a filter in the purification of these gases.

Finely divided palladium is used as a catalyst in hydrogenation and dehydrogenation reactions. It is alloyed with gold to make white gold for the jewelry trade. Like gold, palladium can be beaten into sheets as thin as 1/250,000 inch.

Palladium has recently ranged in price from $130 per troy ounce to near $200.

NUCLEAR REACTIONS.

When palladium is properly prepared and used as a cathode (connected to the negative terminal of a battery) immersed in heavy water (deuterium oxide) together with a platinum or a nickel anode (connected to the positive terminal of the same battery) deuterium ions can be packed into the palladium metal lattice. Under some conditions (with the presence of lithium in the electrolyte) the palladium deuteride (similar to palladium hydride that is formed in palladium when hydrogen is used) supports one or more nuclear reactions. These reactions are not as yet fully understood.

Under the proper experimental conditions, within a specific type of palladium metal lattice (crystal structure) and in the presence of lithium, the deuterium atoms periodically fuse and the resulting energy shows up as heat in the palladium electrode. The nuclear reactions are beginning to be understood and controlled. The following known or suspected nuclear reactions are being reported:

Deuterium + deuterium --> ^{3}He + neutron + energy.

Deuterium + deuterium --> tritium + proton + energy.

Deuterium + deuterium --> ^{4}He + energy.

Lithium 6 + deuterium --> 2 ^{4}He + energy.

The first two have been previously observed in hot fusion experiments in almost equal numbers. In some types of fusion cells the neutron-producing reaction ceases when the current is raised to exceed 150 mA/sq cm of cathode surface. The third reaction has been previously observed only at very low rates of occurrence and is controversial. The fourth reaction is expected to occur at the surface of the Pd cathode. In the last two cases, the helium 4 produced is the isotope of helium normally found in nature. These last two reactions are the most favored because they produce large amounts of energy and no harmful radiation byproducts.

The following indicates how the energy produced can be calculated:

Deuterium + Deuterium = Helium 4 + Energy
2.014 + 2.014 = 4.0026 + 0.0254 (atomic mass).

When the two deuterium atoms combine into helium there is an atomic mass fraction that is converted into energy. By using the famous Einstein equation:

$E = mc^2$

which states Energy = the atomic mass fraction multiplied by the speed of light times the speed of light. This mass fraction conversion to energy is apparently transferred to heat in the palladium electrode. One or more of the four nuclear reactions (or a similar nuclear reaction) is apparently responsible for the production of bursts of heat of up to fifty times as much heat output in the fusion cell as compared to the energy input into the fusion cell.

Other nuclear reactions may be taking place in the palladium (such as neutron capture by Pd and the change of one Pd isotope into another Pd isotope.) However, the helium 4 reaction is preferred because there are no other atomic by-products such as the expelling of a neutron (atomic particle with the mass of a hydrogen atom but having no charge) or the production of tritium (which is radioactive). Large amounts of neutrons are harmful to living tissue and are not a desirable by-product. Tritium gas is poisonous when ingested. Tritium is also radioactive but the nuclear by-product is a beta particle which can easily be shielded.

There is now evidence that the neutron-producing reactions can be controlled by varying the current flow through the fusion cell. In addition, the use of a nickel anode appears to enhance the production of tritium while a platinum anode seems to favor the heat production which is probably due to the helium 4 nuclear reaction.

For this position paper, it is assumed that the solid-state nuclear fusion reactions can be controlled and that a reasonable level of energy can be safely produced.

NUCLEAR GENERATION OF HEAT

The current embodiments of experimental solid-state fusion power are producers of low-level heat (low temperatures as compared with industrial boilers that produce super-heated steam). For the current fusion power to become practical, engineers will design devices that will produce more heat and be able to remove or use the heat at higher temperatures. Alternatively, the fusion heat will be directly converted to electrical energy.

Some of the current experiments are producing a reported 5 to 50 watts of heat energy per cubic centimeter of palladium. A desired goal is to achieve 1,000 watts of energy per cubic centimeter of palladium. The engineering techniques (heat exchangers) used to get 1,000 watts of heat out of a cubic centimeter of palladium have not been fully designed.

PRACTICAL ENERGY LEVELS

For the purposes of this position paper, it is assumed that a practical design for a palladium/deuterium nuclear reactor will be produced that will remove 100 watts of continuous heat energy per cubic centimeter of palladium. Improvements will be made later.

Ten cubic centimeters of palladium will produce one kilowatt of power per hour in a properly designed nuclear reactor. With some inefficiencies, this power could be converted into about one horsepower of heat energy.

An engineering estimate for weight is ten to fifty pounds of reactor per usable horsepower. If a fusion reactor were to be used to power an American automobile the reactor would weigh 100 to 500 pounds. The reactor energy may be used to charge batteries in order to make an auto with simplified parts (as compared to the complex internal combustion engine used today). Alternatively, a fusion reactor could create steam to run a steam-driven auto.

PROBLEMS AND TIMING OF SYSTEM DEVELOPMENT

Most reports cite erratic results (similar experiments do not produce the same results). Some reports cite bursts of energy (heat is not produced uniformly). The lack of controllability (not being able to turn an experiment OFF and later turn it ON) is one of the basic problem that must be resolved before fusion power systems can be made commercially. The current technology is similar to early days of solid-state semiconductor work in the development of useful transistors. However, the problems of control and replication will soon be resolved.

Other unknowns, such as whether or not the crystal lattice of the palladium gradually becomes non-operative; the

temperatures at which the deuterium will not remain in the lattice; and the role of lithium in the production of excess heat, all require more experimental and theoretical efforts. These are considered to be problems that will affect the timing of the eventual developments of useable solid-state fusion systems and not whether such systems are eventually developed. Based on some long-term experiments, cells are expected to last for 6 months to one year before refurbishing is required.

The current experimental state of solid-state fusion (as soon as the controllability and reproducibility problems are solved) indicates that solid-state fusion energy systems can be designed which have at least the same energy density (power generated per cubic meter of plant) as is achieved in coal-fired power plants.

EARLY ENGINEERING DESIGN GOALS

For the purposes of making technological impact predictions, it is assumed that engineers can produce useable energy using solid-state fusion nuclear reactors. The estimate of size and weight (an early engineering design goal) is 100 pounds in weight and two cubic feet in size for each kilowatt or horsepower of power.

Later design goals would be to reduce this weight and volume by a factor of ten to achieve a reactor of ten pounds per horsepower and packaged in a smaller volume of space.

It is forecast that initial commercialization will be for smaller solid-state fusion systems where the production of low-levels of heat (of the order of 300 to 500 degrees Fahrenheit) is sufficient. Therefore, home heating and cooling applications and applications for the direct conversion of heat to electrical power are expected to precede the larger industrial applications of solid-state fusion systems. However, scale-up experiments for power generation are already being done experimentally in India.

COSTS OF OPERATION

For the purposes of calculating energy costs in 1990 prices the following assumptions will be made.

* Palladium will cost $200 per troy ounce.

* Deuterium will cost $1000 per gallon.

* The fuel conversion efficiency of deuterium (and/or lithium) to usable energy will be ten percent.

* The maintenance costs will be ten percent per year of initial fabrication/installation costs.

* Services for purifying and reforming palladium will be readily available and are included in the "maintenance costs".

* Initially, it will require ten cubic centimeters of palladium to produce a continuous one kilowatt-hour of energy.

CONVERSIONS FOR CALCULATIONS

1 cubic centimeter of palladium weighs 10.6 grams.

1 troy ounce is 31.1 grams.

1 cubic centimeter of palladium weighs about 3 troy ounces.

1 cubic centimeter of palladium will cost $600.

ENGINEERING ESTIMATES

Early reactors will cost $5,000 per kilowatt and reduce to $1,000. Maintenance costs will be $1,000 per kilowatt per year and reduce to $200 per kilowatt per year. The cost of capital will be ten percent per year.

The cost of fuel will be about $0.01 per kilowatt hour. The energy values are roughly 300 gallons of fuel oil per gallon of ordinary water or two million gallons of fuel oil per gallon of deuterium oxide. At ten percent efficiency and at $1,000 per gallon the equivalent cost of fuel would be about one cent for the energy equivalent in one gallon of fuel oil.

CALCULATION OF COSTS FOR HOME SOLID-STATE REACTOR

Utah Power and Light report that the average Utah home uses 550 kilowatt-hours of electrical energy per month. Assuming a cost of $0.10 per kilowatt-hour, the average monthly electrical bill would be $55.

Assuming that a home solid-state fusion reactor produced continuous power and used storage batteries for peak load, the initial cost of a one kilowatt reactor installation would be $5,000. At ten percent interest rate the cost of capital would be $ 500 per year. The maintenance cost would also be $1,000 per year. This $1,500 cost would exceed the typical electrical home bill of $550 per year.

However, as the costs of the solid-state fusion reactor lowered, the home fusion reactor would become a viable alternative as compared to the current cost of electrical power.

Calculations based on a fusion reactor that would cost $1,000 to buy and install and $200 per year for maintenance shows that the annual cost (including cost of

capital) would be about $300 per year. This amount would be considerably less than the cost of electrical power.

The above calculations do not consider the cost of "fuel" because fuel costs are negligible in comparison to equipment costs, cost of capital, and maintenance costs.

In general, it is expected that the combination of rapid engineering developments of solid-state fusion systems together with the relatively low entry cost to the manufacturer for entering the business will lead to the effective construction and use of medium and small solid-state fusion reactors within three to five years.

NEW DISCOVERIES WILL SUPPORT SOLID-STATE FUSION

Few researchers have reported the successful use of any other metal than palladium to replicate the effect discovered by Pons and Fleischmann -- that excess heat was generated. A verbal communication with Mr. Maitra, editor of FUSION ASIA reports that titanium cathode with sodium deuteroxide produces excess heat.

A reasonable technological forecast is that metals other than palladium will be found to support solid-state fusion. It is likely that optimum results will be found by using a combination of metals (an alloy) that will support solid-state fusion but be more predictable and less expensive.

The position of this paper is that the combination of the results of intense interest, plenty of research funds, and many scientists working in the field will lead to rapid development of solid-state fusion systems. Therefore, the following developments are expected:

* The discovery of other metals or of alloys that will support solid-state fusion.

* Increases in output temperatures in operating fusion reactors.

* Improvements in direct heat-to-electricity conversions.

* The gradual lowering of the costs of fusion reactors.

* The control of the type of nuclear reaction taking place. (For example, neutron production decreases or stops when the cathode current is increased).

* A continuation of the low cost of entry into the solid-state fusion industries.

* A rapid growth in specialty companies to serve the industry. For example, in production and marketing of heavy water, reactor electrodes, safety devices, instrumentation, etc.

* The rapid development of engineering prototypes of new systems based on solid-state fusion developments.

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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!"

A LITTLE LATE BUT:
TITLE AND ABSTRACT SHOULD BE SENT TO:

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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