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SPECIAL REPORT ON THE PAPERS:

ANOMALOUS NUCLEAR EFFECTS IN DEUTERIUM/SOLID SYSTEMS CONFERENCE
Brigham Young University - OCT 22-24, 1990

MOST IMPORTANT PRESENTATION: HELIUM 4 FOUND IN ELECTRODE USED IN MOLTEN SALT CELL!

ALL B.Y.U. CONFERENCE PAPERS PRESENTED, EXCEPT PAPERS ON GEOLOGICAL COLD FUSION, ARE REVIEWED IN THIS SPECIAL ISSUE.

REFINEMENTS ON COLD FUSION THEORY ARE REVIEWED.

COMING NEXT MONTH:

GEOLOGICAL COLD FUSION
NCFI SCIENTIFIC REVIEW
REVIEW OF WHEC#8 PROCEEDINGS
REVIEW OF LATEST PUBLICATIONS

ARTICLES:
Beryllium as Witnessing Agent.
Neutron Detection.
Review of CF Progress.

ERROR CORRECTION:

***Fusion Facts*, Vol 2, No 4, Oct 1990 page 15 incorrectly indicates that Dr. Criddle obtained excess heat. Page 21 incorrectly identifies Ruder Boskovic Institute as reporting neutrons. The group reportedly was at the Vinca Institute in Yugoslavia.**

CONTENTS FOR NOVEMBER 1990

A. HELIUM-4 FOUND IN Pd ELECTRODE

The most important cold fusion announcement made at the recent BYU conference was the joint announcement by Dr. Nate Hoffman (as both Chairman of the General Papers session and a member of the laboratory performing the measurements) and Dr. Bruce Liebert of finding significant amounts of ^{4}He in a Pd electrode. The report follows:

Prof. Bruce Liebert (U of Hawaii).

[The experiment, which yielded very high levels of excess heat and ^{4}He, used a novel molten-salt electrolytic cell. For additional information, refer to *Special Symposium Proceedings, COLD FUSION*, World Hydrogen Energy Conference #8 (July 1990) or the October 1990 FusionFacts. Ed.]

Professor Liebert reported that the molten salt cell differs radically from typical electrolysis cells in that the operating temperature is greater than 350 C, and the electrolyte is molten LiCl and KCl salts with LiD as a deuterium source. The system is extremely reducing (oxygen activity < 10^{-30}) so that ordinary transition metals which would ordinarily form a hydrogen-blocking oxide film can also be used. It was noted that the temperature was above the critical temperature for the alpha-beta phase transition in Pd, which had been suggested by some other researchers as possibly aiding in the fusion process. **The deuterium is transported as an anion; the metal of interest is run as the anode rather than the cathode.**

Data for a Pd experiment showed excess power (excess heating relative to electrical power input) increasing with current density; at 692 mA/cm^2 the power gain was approximately 1500% (25 W). The excess heat totaled over 1000 MJ/mole Pd in approximately 100 hours, and could presumably have continued longer except that the LiD in the cell electrolyte had been exhausted.

No tritium or neutron measurements were made during this of this experiment. However, Dr. Nate Hoffman of Rockwell measured ^{4}He by mass spectrometry in 4 segments of the above electrode, as well as two segments of another electrode from the same source which had not been electrolyzed. An LiH control Pd electrode is still to be measured. One of the reasons for analyzing and reporting the various segments individually was the possibility of a nonuniform distribution of fusion products, such as was seen, for instance, by the BARC, India group. The two blanks yielded 0.2-0.3x10^9 atoms of ^{4}He, similar to the background of 0.1-0.7x10^9 atoms. The 4 samples yielded 0.6, 0.6, 0.8, and 2.8x10^9 atoms; the latter is 14 sigma above background. However, as discussed afterwards, the inferred 4x10^{10} fusion events, while clearly significant, are far less than would be needed to account for the heat generated by this anode; thus if ^{4}He is the primary product of the heat-producing reaction, the majority of the helium was not retained in the electrode (due to a surface mechanism, porous electrode, etc.).

EDITOR'S COMMENTS

This announcement is of fundamental importance in the advancing discoveries in cold fusion as it was the first, to our knowledge, of significantly large numbers of ^{4}He to be measured in a spent palladium electrode. We strongly urge all cold fusion research groups, who have personnel experienced in working with molten salts, to replicate this important experimental work. Please note that replication is not simple. Similar to the heavy water electrolysis experiments, the pre-treatment of the palladium electrode appears to be the key factor in achieving large amounts of excess heat.

B. COMMENTS ON BYU CONFERENCE

In this special issue of *Fusion Facts* we are pleased to present a review of most of the papers presented at the recent BYU international progress review on ANOMALOUS NUCLEAR EFFECTS IN DEUTERIUM/SOLID SYSTEMS.

The papers reviewed are organized according to the following subjects: Neutron Measurements, Charged Particle Detection, Tritium Measurements, Theory, and Miscellaneous Papers.

Papers are arranged, under these headings, alphabetically by presentor. Where available, abstracts are reprinted, followed by comments made by the presentor. Square brackets denote editors' comments as contrasted with the reporting or paraphrasing of comments from the author.

The conference was attended by over 150 scientists from the U.S. and 15 other countries. Attendees included 16 from Italy, 10 from Japan, and 6 from the People's Republic of China.

Nearly all non-theory papers reported positive results in the measurements of byproducts of nuclear reactions. The papers were divided between reports of on-going efforts and initial reporting of new experimental work. Publication of proceedings of this conference will be another excellent addition to literature of the emerging science of cold fusion.

C. NEUTRON MEASUREMENTS

LOS ALAMOS - EXPERIMENTAL ERRORS

R.E. Anderson, C.A. Goulding, M.W. Johnson, S. Gottesfeld, D.A. Baker, T.E. Springer, F.H. Garzon, R.D. Bolton, E.M. Leonard, and T. Chancellor (Los Alamos National Laboratory), "Neutron Measurements In Search Of Cold Fusion," Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Three types of neutron measurements have been performed in support of cold fusion experiments. These three types of measurements are (1) integral neutron counting using a high-efficiency well counter; (2) spectral measurements using an NE 213 scintillator; and (3) burst measurements, using the well counter, searching for high-multiplicity, short-duration events. The counting system was segmented to perform checks on the operation of the various components. Experiments included automatic data

acquisition for all measurement techniques. Data were obtained both above ground and in a shielded room approximately 50 ft. underground. No evidence for the production of neutrons above the background levels was found when electrochemical cells and, to a lesser extent, high-pressure gas cells were used.

A careful study of the neutron background was conducted both above ground and in the underground room. These experiments used empty counters and counters filled with various materials, such as a lead brick. The background studies produced results for all three types of neutron measurements. These results strikingly resemble data that has been considered evidence for cold fusion, specifically:

(1) In the integral count rate data, three- to seven-sigma fluctuations above the average background rate occur at rates far in excess of the statistical predictions;

(2) Weak peaks near 2.5-MeV neutron energy were observed in the background; and

(3) High-multiplicity neutron events attributable to cosmic rays are commonly observed.

We will show that simple observations of data of these three types are, of themselves, insufficient to indicate that processes other than background are occurring. Our data also allow us to comment on the effectiveness of several experimental approaches: Measuring the barometric pressure and using segmented counting systems are highly recommended. However, using two identical side-by-side counters, one for the cold fusion cell and the other for the background, may not be useful under certain conditions.

COMMENTS

[The experiment described by Dr. Anderson illustrates possible systematic errors that can occur in neutron measurements if the effects of cosmic rays and malfunctions are not properly controlled. Ed.]

The neutron well counter described consisted of 20 ^{3}He tubes with polyethylene moderator, surrounded by Cd and polyethylene shielding. The background count rate was 0.33/sec and the efficiency was approximately 22% (dependent on the neutron energy). The NE213 background rate was 1-1/2x10^{-3}/sec and the efficiency was 1% (with 1 MeV threshold to give good gamma rejection).

In the three above-ground background spectra, count rates in 30 of the 265 100-minute intervals were more than 3 sigma above the mean. The maximum deviation was approximately 0.08 counts/sec, equal to 7 sigma. In contrast, if the background count rate had followed the expected Poisson distribution, only 1 deviation of 3 sigma would have been expected. Furthermore, in several cases a sequence of successive values were high. Bursts with multiplicity up to 28 counts (= 150 source neutrons per burst) in 10^{-6} seconds were also seen. In contrast, the background count rates in the underground lab showed much better agreement with the Poisson distribution; only 1 100-minute interval in 3 weeks was more than 3 sigma from the mean. (Also, the background was considerably reduced even at the depth of 50 m.)

The count rates of each of the 5 segments of the counter were also compared to make sure the counter was well behaved; this was necessary to eliminate episodes of spurious counts. For example, count rates jumped from 1.5/sec to > 80/sec when a preamplifier overheated.

Finally, a feature at 2.5 MeV was seen in the background spectra; this averaged 3 sigma above background over a 68-hour period, but only in one of the two counters.

The systematic background variations in the aboveground measurements were due to the strong inverse correlation of count rates with barometric pressure. This variation was calculated at -0.8% per mm Hg in this experiment; a similar value of -.94% per mm is in the literature). Thus, it was noted that daily barometric pressure variations can cause systematic errors in low-level work at aboveground sites if backgrounds are normally acquired at one time of day and samples at another.

In the subsequent discussion, the use of high voltage, moisture, and EMI protection was recommended- this was not done in the above experiment. Also, it was indicated that the Figure of Merit (relating sensitivity to background count rates) which is calculated for a counter would need to be modified depending on whether the count rate is dominated by the background or the signal.

CZECHOSLOVAKIA - HIGH ENERGY NEUTRONS

P. Bem, I. Paseka, I. Pecina, V. Presperin, O. Spalek, M. Vomacka, & J. Vondrak (Inst. of Nucl. Physics & Inst. of Inorganic Chem., Czechoslovak Acad. of Sci., Prague, Czechoslovakia), "Search for Neutrons from DT-Cold Nuclear Fusion", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT (Paper not presented)

As a possible low-background test of cold fusion a search for 14 MeV neutrons from D+T reactions in a D_2O + LiOD electrolytic cell was performed using a pulse-shape hardware-threshold stilbene scintillator system. The

cathode consisted of a commercially available Ti-T layer (1.4-1.7 mg per cm^2, 8 cm^2 area) on a 0.1 cm thick molybdenum disk. Pulse height distributions of signals at neutron energies from 3 to 18 MeV have been stored in one-hour periods. A very low background of average count rate 0.9 counts per hour (3 sigma deviations 1.8 counts per hour) has been achieved at energies between 6.5 and 14 MeV. In some periods of foreground runs a counting rate from 2 to 6 counts per hour above background has been observed at these energies. No time-correlation with these fluctuations was seen at higher energies. The run performed with H_2O instead of D_2O has also shown no three-sigma deviations from background. Summing signals from such periods we have found the pulse height distribution corresponds well to the proton-recoil form of a 14 MeV neutron spectrum. It has been proven that the random instability of the cosmic-ray separation threshold leads to forms of spectra conspicuously different from that of 14 MeV neutrons. We confirmed this recently in a background experiment, performed with the pulse-shape versus pulse-height registration system.

We therefore ascribe the observed foreground fluctuations to possible emission of neutrons from D+T fusion. A maximum counting rate of 6 counts per hour above background corresponds to the neutron-source strength of 1300 neutrons per hour or to the fusion rate of about 4×10^{-21} fusions per sec. taking into account the content of 9×10^{18} atoms of T in corresponding Ti-T sample and the detection efficiency = 0.0045 of the present experiment.

Our results support very low levels of DD-fusion in a crystal lattice, observed by Jones et al. Being above two orders of magnitude larger than the DD-rate from Jones' report, the observed fluctuations in the DT-rate may indicate the unstationary fracture origin of crystal-lattice fusion as predicted by Cohen & Davies and independently by Gerstein & Ponomarev.

ITALY - HIGH SENSITIVITY DETECTOR

Antonio Bertin (U of Bologna, Italy), "A Novel Apparatus to Search for Electrolytically Induced CF- Neutral Products in the Gran Sasso Lab"

COMMENTS

[Improved neutron detection methods designed to replicate previous Ti gas-loading experiments are described. No abstract was available. Ed.]

In the original work, performed in conjunction with Dr. Jones of BYU (reported at the Santa Fe conference, in Il Nuovo Cimento 101A, p 997, 1989, and in the Journal of Fusion Energy 9, p 211, 1990), 0.2 neutrons/sec were measured, with estimated energies consistent with conventional d-d fusion (2.5 MeV), using a proton recoil scintillator with good gamma discrimination (using pulse shape analysis). However, the signal-to-noise ratio was only 0.18, since some gammas were still not distinguished from neutrons.

Accordingly, the experiments were repeated in the Gran Sasso underground laboratory using additional low-activity Pb shielding to reduce the gamma background by an additional factor of 6, and new, dedicated neutron counters (to allow long-term background data to be acquired). These were larger NE213 counters with better n-gamma pulse shape discrimination, and a new coincidence neutron spectrometer with 2 phototubes (also with n-gamma discrimination, checked with an Am-Be source). The latter used coincidences between the initial signal in the scintillator due to proton recoil and the following signal from thermal neutrons reacting with ^6Li to produce ^4He+T [as in the detector described by Czirr]. When operated in the coincidence mode, background count rates were 150 times lower (6.5 times 10^{-4}/sec versus 10^{-1}/sec) and gamma discrimination was 12.5 times better, but efficiency was only 0.045 times as great at 2.5 MeV (0.7% versus 15%). Finally, further improvements, such as requiring the amplitude of the delayed signal to also be of an appropriate energy for the neutron capture reaction, have since reduced the background counting rate down to 6×10^{-6}/sec; this translates into only 3 background counts in the latest 140-hour background run.

With the new spectrometer, the 0.01 counts/sec signal seen in the original experiment would have given a signal-to-noise ratio of 80 rather than 0.18, even though the count rate would have dropped from approximately 35/hour to 2/hour. The count rate on the new NE213s would have been over 30/hour.

ITALY - HIGH TEMP. SUPERCONDUCTOR

Francesco Celani (Istituto Nazionale Fisica Nucleare, Laboratori Nazionali di Frascati, Italy), "Measurements in the Gran Sasso Laboratory"

COMMENTS

[These latest experiments involve gas loading of high-temperature superconductor; neutron production was monitored during cycling between 77 K (the superconducting state) and 300 K (room temperature). No abstract was available. Ed.]

The neutron flux in the Gran Sasso underground lab, measured at $10^{-6}/cm^2$/second, was reduced by 3 orders of magnitude. The gamma flux was reduced 10-fold, with a further 5-fold reduction achieved using low-activity Pb shielding.)

Superconducting $YBa_2Cu_3O_{7-x}$ (critical temperature 93 K) was tested because of several similarities which were noted with hydrided Pd, and the fact that these materials also possess a reduced dimensionality which might enhance the fusion rate under appropriate conditions, as suggested by Dr. Mario Rabinowitz (Modern Physics Letters B3, 1990) and G. Dattoli et al (ENEA RT/89.49 preprint). (As reported by J.E. Schirber and C.J.M. Northrup, Phys. Rev. B 10, p 3818, 1990, Pd itself only becomes superconducting when loaded to H/Pd or D/Pd ratios greater than 0.8, i.e. beyond the beta phase, but the maximum critical temperatures, reached at highest loading, are only 8 K for PdH and 10 K for PdD. The higher temperature for the deuteride than the hydride was noted to be unusual.)

A study was also cited (H. Niki et al, Solid State Comm. 63, p 547, 1989) which found hydrogen in the lattice to move dynamically at 170 K but become trapped below 150 K, giving reason to expect that a possibly sudden movement may occur during the warming. A previous study of the effect of hydriding and deuteriding on the superconductivity has been reported by J.S. Reilly, P.R.B. 36 (10), p 5694, 1987.

In the experiment, 6-10 g of sintered material was loaded with D_2 (35 bar) while warming from 300 to 371 K. It was then cooled to 358 K, then after 3 hours cooled further to 300 K (i.e. room temperature) in a few minutes. The D_2 pressure was increased to 36 bars and neutron detection was started. After cooling to 77 K, the material was warmed to 300 K again over 1 hour. Loading was estimated to range from 0.4 to 5 deuteriums per formula unit. (Loading in excess of 2 deuteriums destroys the superconductivity, however.)

Neutron emission (maximum 10 counts) was observed during warming at approximately 100 K, using two ^{3}He tubes with independent electronics. (Pulse shapes could be examined with a digital storage oscilloscope. The background was 1 count/hour and the efficiency 0.6%.) The emission decreased strongly in successive cycles (stopping altogether by about the tenth cycle). After the sample was reloaded at 371 K, emission was seen again, but at a lower level. (It was noted that a neutron burst, with several hundred counts, was also observed by Dr. Jones of BYU after a sample of this material and Ti deuteride were squeezed and immersed in liquid nitrogen.) The effect of exposing the material to a 2.2 KBq Am-Be neutron source was also tested. Controls were undeuterated material and deuterium gas. Neutron emission was 3 standard deviations above background ($73+/-26X10^{-3}$/sec excess).

(Earlier experiments involved electrolysis with Pd and Ti-Al cathodes in D_2O + 0.1 M LiOD at current densities of 60 mA/cm^2; neutron and gamma bursts were simultaneously observed, using several ^{3}He and NaI detectors, in electrodes which had been annealed and degassed at high temperature. Calculated fusion rates were on the order of 10^{-19}/d-d pair/second. In addition, gaseous CO_2 was used in some tests to enhance fracture rates.)

[The article by Dr. Rabinowitz proposing the use of high-temperature superconductors may also have been the first to suggest that a d+d+d fusion mechanism might be likely in a lattice environment. Ed.]

BYU - HIGH EFFICIENCY DETECTORS

J. Bart Czirr and Gary L. Jensen (Brigham Young U), "High-Efficiency Spectrometers and Detectors", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

A series of efficient, low-background neutron detectors has been designed and built at Brigham Young University. These detectors are based upon a coincidence-calorimeter principle and are suitable for measurements of weak sources of MeV neutrons in which the neutrons are emitted singly or in bursts. A low-efficiency spectrometer of this type was utilized for the initial cold fusion experiments at BYU [J.B. Czirr and G.L. Jensen, Nuclear Instruments and Methods in Physics Research, v A284, p 365, 1989]. More recent detectors have greatly improved efficiency and also permit measurements of bursts of neutrons.

The burst-mode detector has an efficiency of approx. 25% for 2.5 MeV neutrons, with a background level of 20 neutrons per hour. The high efficiency is achieved mainly by providing a 1 1/2 inch diameter cavity in the detector body. Another detector in the series is a combination spectrometer/burst mode detector with efficiency of about 20%, depending upon the type of organic scintillator employed. The spectrometer mode is useful for detecting single neutrons in the 1-14 MeV range. The burst mode feature, which may be used concurrently with the spectrometer function, is useful in detecting bursts of two or more neutrons and has low background rates.

A summary will also be presented in which existing neutron detectors will be compared in terms of a proposed figure of merit.

COMMENTS

[This presentation by Dr. Czirr (and that of Dr. Menlove) describe neutron detectors particularly well suited for cold fusion experiments. Ed.]

The initial (burst-mode) detector described contained a plastic scintillator core viewed by one phototube, with the sample cavity in middle, and also a mineral oil bath with another scintillator optically isolated from the first and viewed by 2 phototubes; the signals from the phototubes are summed. A portion of the neutrons should react in the plastic scintillator to give a sharp start pulse. Then, neutrons in the burst are conveniently separated in time by the glass scintillator, which has a suitably long mean capture time. Also, the neutron capture in the glass involves a monoenergetic 4.8 MeV reaction [^{6}Li(n,alpha)t], allowing the signal to be distinguished from gamma events.

If the detector is designed such that the neutrons lose all of their energy within the scintillator, and the signal due to neutron capture in the glass is required to also be present (thus indicating that the signal was due to a neutron), the pulse height information allows the system to be used as a crude energy spectrometer as well as a burst mode detector. As the decay times of the signals in the glass and organic scintillators are 20 and 5 microseconds, respectively, pulse height analysis can also allow more sophisticated tests, leading to elimination of more of the background counts. (All information is recorded in 10 microsecond units with a waveform digitizer.) For example, the amplitude of the stop pulse should be consistent with capture in glass, and the size of initial event should be correct (for example, thermal neutrons can be eliminated in this fashion.)

The actual response of the latter detector was also tested using the Colorado School of Mines accelerator. Efficiency was lower for higher-energy neutrons- for example, it dropped to 5% for 14 MeV neutrons.

An example of a charged particle detector was also described. This device is constructed of three layers: plastic scintillator (thickness 1.57 x 10^{-2} g/cm^2), Si glue (0.73X10^{-2} g/cm^2), and glass scintillator (37.5x10^{-2} g/cm^2). The thicknesses are such that the energy of a 5 MeV proton would drop to 3.52, 2.67, and 0 MeV, respectively, in passing through the above layers. Thus, it would be possible to discriminate between tritons and protons: tritons would stop completely in the plastic scintillator. (Regarding the glue composition, it was also suggested that an organic glue would be preferable to the Si glue initially used.)

USSR - NEUTRONS FROM LiD DISSOLUTION

M. Danos (National Institute of Standards and Technology), "Neutrons from Chemical Reactions", reporting for A.V. Arzhannikov and G.Ya. Kezerashvili (INP, Novosibirsk, USSR)

COMMENTS

[The experiments described indicated reproducible neutron emission during LiD dissolution in D_2O. No abstract was available. Ed.]

Neutron emission was observed in nearly all trials in which LiD crystals (a few mm in diameter) or powder were dropped into D_2O. Controls using LiH or H_2O were negative. Count rates were up to 20-30 per 30 seconds, versus 0-10 per 30 seconds in the background. Background counts closely fitted a Poisson distribution, while experimental data was far from it.

ARGENTINA - PULSED ELECTROLYSIS

J.R. Granada, R.E. Mayer, P.C. Florido, G. Guido, V.H. Guillette, S.F. Gomez, N. E. Palino and A. Larreteguy (Centro Atomico Bariloche, Argentina), "Neutron Measurements on (Pd-D_2O) Electrolytic Cells Under Pulsed Current Conditions", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

We present in this work the results of neutron measurements performed on electrolytic cells containing deuterated Pd cathodes, using a high efficiency thermal neutron detection system in combination with a procedure involving a non-stationary current through the cell's circuit.

Experiments carried-out at our laboratory over a long period revealed a low level neutron production correlated with the current pulses, giving rise to characteristic patterns which were strongly dependent on the previous charging history of the cathodes employed.

Another set of measurements was performed with essentially the same experimental set-up, but on board of a submarine 50 m under the sea surface. A very low background level was attained under these conditions, thus yielding a much improved signal-to-noise ratio as compared to our ground laboratory situation. The counting rates observed in the measurements on cells containing deuterated Pd cathodes are well separated from those obtained in test (H_2O, background) runs.

COMMENTS

[This presentation by Dr. Granada discussed a Pd electrolysis experiment in which neutron emission a few sigma above background was measured. Ed.]

Current densities were cycled between 0 and 31-91 mA/cm^2 at 150-second intervals, and neutron count rates during the two sets of time intervals were then compared, in order to average out significant longer-term fluctuations in the background count rate. After the initial, inconclusive, aboveground measurements, the experiment was repeated onboard a submarine (at depths of 50-100 m or more, to reduce background levels approximately 50-fold). 68 3000-second runs were performed using four D_2O and one H_2O cells; three of the D_2O cells averaged 1.44+/-.12X10^{-3} counts/sec (3 sigma above the control), versus 1.13X10^{-3}/sec for the fourth and 0.97X10^{-3}/sec for the H_2O control cell. Further runs are also planned.

Neutrons were measured using 2 sets of 6 ^{3}He tubes with paraffin moderator (efficiency approximately 12%); the tubes were sealed against moisture and signals due to power line noise were eliminated by running the sets of counters in anticoincidence mode (instances in which signals were registered on both sets were rejected). [It should be noted that the use of coincidence techniques for sample counters and anticoincidence techniques for veto counters to eliminate line noise is far more common. Also, some previous experiments suggest that periodically switching the current off may interfere with development of the effect. Ed.]

ITALY - TIME OF FLIGHT SPECTROMETER

F. Iazzi (U of Tolino, Italy), "Neutrons Detected using TOF"

COMMENTS

[A preliminary Ti gas-loading experiment was performed in an attempt to detect production of neutrons and/or tritium; results were inconclusive but further experiments are planned. No abstract was available. Ed.]

Three g of Ti shavings were loaded in 2 atm of D_2, and the temperature was cycled 12-15 times (with cycles lasting 22-24 hours). At low temperatures, neutron count rates in the 2.4-2.8 MeV energy interval were 3 standard deviations higher than in an H_2-loaded control (corresponding to 2 neutrons/sec) , measured using multiple scintillation counters. However, decreases in the count rates at other energies were nearly as great. (Initial neutron energies were based on time-of-flight [TOF] information calculated by comparing the responses of the scintillators.) 6.6x10^7 tritium atoms/ml were reported, but no data from a control was available.

In the subsequent discussion of the interesting neutron measurement technique, it was noted that with typical times between 2 scintillations of 34-66 nsec, it was possible to eliminate nearly all of that portion of the background produced by relativistic particles.

BYU - BURSTS IN COLLABORATIVE STUDIES

Steven E. Jones, E. Paul Palmer, J. Bart Czirr, Daniel Decker, Gary Jensen, James Thorne, Stuart Taylor, Douglas Bennion, William Pitt, John Harb, Dennis Tolley, J.C. Wang, Russel Hunter, David Buehler (Brigham Young University), Howard Menlove, Michael Paciotti (Los Alamos National Laboratory), Peter Jeschovnig (Colorado Mountain College), "Investigation of Anomalous Particle Emissions in Solid/Deuterium Systems", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Beginning with an early treatise published in 1986 [J. Phys. G 12, p 213], we have written several papers relating to 'cold fusion', or nuclear effects realized in deuterium/metal (d/M) systems [Nature 338 p 737, Nuovo Cimento 101 p 997, and others]. In particular, we have developed new specialized detectors and replicated with colleagues neutron production reported in *Nature* last year. Studies of tritium and helium production in d/M and geological systems also continue.

This report focuses on recent results obtained in a deep mine with a segmented neutron counter. The detector incorporates sixteen helium-3 filled proportional counter tubes embedded in polyethylene moderator and divided into 4 segments. The counter was utilized for seven weeks in the Asarco lead mine in Leadville, Colorado at a depth of about 600 m below the surface. The background level (due almost entirely to decay of radioactive trace elements in proportional-counter tube walls) was found to be stable and close to 76 counts per hour. Signal rates as high as 150 source neutrons per hour (average above background) were obtained in D_2O-electrolytic cells and deuterium-gas charged titanium chips with all four segments showing signals in balance. Episodes of significant neutron production lasted from 1.5 up to 40 hours, consistent with previous results. A high-sensitivity detector is required to identify such signals; the detector efficiency was evaluated to be 34% using a californium-252 source. Five microbursts of neutrons were also observed in 3 weeks of d/M tests, with multiplicities up to 300 neutrons in a 128 us window. The background for such correlated events is very small:

only one correlated event was seen in nearly 3 weeks of background runs, and this was small -- only 2 counts registered in the 128 micro-sec window.

Sources of spurious signals in the detector were also studied. For example, high rates observed in segment 4 proved to stem from humidity entering the segment. The use of a segmented detector in a near-zero cosmic-ray environment proved effective in eliminating spurious effects.

We conclude that anomalous neutron emissions from deuterium/metal systems are observed. These results cannot be ascribed to low-statistics or to cosmic-ray effects.

The assistance of H. Menlove and K. Wolf, both of whom entered the mine with signal-yielding d/M cells, is gratefully acknowledged. P. Jeschovnig of Colorado Mountain College in Leadville also participated, as did J. Wang, S. Taylor, D. Buehler and other members of the BYU research team. This research is supported by the U.S. Department of Energy, the Electric Power Research Institute, and Brigham Young University.

COMMENTS

[Dr. Jones' presentation described collaborative work in which neutron bursts were measured from several different electrolysis and gas-loading experiments. Ed.]

The type of detector used was similar to that of Menlove, and similarly portable to allow it to be taken into the mine for the 7 weeks of experiments mentioned. (Dr. Jones also noted that Dr. Menlove had worked on such detectors for 20 years.) The advantage of using correlated counting modes and underground sites was made extremely clear by a comparison of background counting rates. (The singles count rate of 75/hr 600 m below the surface compares with 400/hr in the underground lab at BYU and 23,400/hr at the surface at Leadville. The correlated count rate of .05/day in the mine was 10^5 times less than the rate at the 300/hr surface at Leadville and 3-1/2 orders of magnitude better than the 7/hr rate at the BYU lab.) Also, as mentioned, the only correlated background count during the 20 days in the mine consisted of only 2 neutrons; thus the background rate for higher-multiplicity events would be expected to be much lower yet. (For purposes of comparison, the shielding provided by the Asarco Leadville mine was approximately 3/4 that of the Kamioka, Japan facility described by Dr. Totsuka and half that of the Gran Sasso, Italy site used by Dr. Bertin.)

As indicated in the abstract, considerable effort was made to eliminate systematic errors due to spurious counts, and in fact the segmented detector with redundant electronics and other precautions allowed all of the deliberately introduced spurious counts to be recognized. (For example, acoustic noise pickup was tested; no response was shown to occur to loud noises or tapping on the detector; an inadvertent sharp blow to the detector did give spurious counts, but these could be seen to be false when registers were compared. Similarly, no response occurred due to the operation of a CO_2 laser using a capacitor bank discharge which generated considerable electromagnetic interference. The interior of the detector contained desiccant and a humidity monitor. As noted, without the desiccant, much higher count rates occurred, although again the redundancy (the 4 segment registers plus the registers used in the count correlation) made it possible to tell the counts were spurious.)

Of the bursts recorded, two occurred during two days of operation of three electrolytic cells from Dr. Kevin Wolf of Texas A&M (6 mm diam. Pd cathode, Ni mesh anode, 0.1 M LiOD, 8 V, low current density). In one cell, no excess neutron production was observed during the first 1-1/2 hours, whereas random (individual) emission of an estimated 150 neutrons/hour (4-1/2 sigma above background) occurred during the second 1-1/2 hours.

A small burst event (2-10 neutrons) was also observed from each of two samples of gas-loaded Ti 6-6-2 identical lathe turnings (approximately 1 mil thick, identical to those which Dr. Jones has provided to many other groups) which were loaded with 2 atm D^2 at 650 C, then cooled in liquid nitrogen just before entering the mine, and from a test in which a sample of high-temperature superconductor (Y-Ba-Cu oxide) and TiD chips, gas-loaded at 300 C, were squeezed with pliers. The latter demonstrates the good agreement possible between the singles counts (370) and the burst register (290) during a burst. Loading of the Ti was apparently in the $TiD_{.02-.20}$ range.

The gas-loaded samples from Drs. Paciotti and Menlove at Los Alamos began to count at up to approximately 15 counts/hr (>5 sigma) above background after D_2 was added in the mine.

In addition, results were also shown from a Pd electrolysis experiment performed at the BYU lab with cells prepared by Dr. Douglas Bennion. During operation at slowly increasing voltage over 3 weeks, one episode with very high counts was observed. The overall count rate for the entire episode was approximately 90 sigma above background, and the count rate died off and increased again during the episode. The average rate over the 3 hours was 3.4/sec, and the total number of source neutrons was estimated to have been 2400.

Dr. Jones expressed his willingness to share detectors, data, samples and ideas, and indicated that he feels interdisciplinary and cooperative effort is needed in this area.

ROCHESTER - SUPERCRITICAL TEMPERATURES

Jacob Jorne (U of Rochester), "Neutrons Emission From Palladium Deuteride Under Supercritical Conditions", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Palladium has been exposed to pressurized deuterium gas at 60 atm and 198 K and the temperature has been raised up to 593 K, beyond the critical point for alpha-beta palladium deuteride. Excess neutrons, beyond the background level, have been observed, while similar experiments with an empty cell or with an hydrogen-palladium cell showed no excess. If the excess in neutrons is due to fusion, a corresponding fusion rate of 10^{-21} fusion per D-D pair per sec. can be estimated. Solid state electrolysis, using deuteron-conducting solid electrolyte, also showed bursts of neutrons under an applied voltage and at 525 K.

Recent results in our laboratory and elsewhere indicate that neutron emission occurs in systems where the deuterated palladium is subjected to stress gradients. It is suggested that stress-induced uphill diffusion of deuterium in palladium, against its concentration gradient, can result in a high ratio of deuterium to palladium, higher than the equilibrium ratio attained at the boundary. Theoretical analysis of stress-induced diffusion of deuterium in palladium shows that high ratios are locally attainable.

COMMENTS

[In the first Pd gas-loading experiment described, slight increases in the neutron and gamma ray count rates were seen as the temperature was raised above the critical point at which a mixture of alpha and beta hydride phases would be converted entirely to the beta phase. In the second experiment, a novel method involving a deuterium-conducting solid electrolyte was used, combining features of both gas-loading and electrolysis experiments. Ed.]

1 g of Pd foil and 1 g of 20-mesh Pd were used in the gas loading. The temperature and pressure cycling was more complex than indicated in the abstract (including, for example, 2 months at room temperature, 298 K). An increase in the neutron count rate (although less than 0.1 counts/sec) was seen within 10 degrees of the critical temperature on each of two NE213 counters (1.25 MeV threshold, 7% efficiency, background .03+/-.005 counts/sec). Simultaneously, the gamma count rate increased from approximately 73 to 81/sec. It was indicated that the control experiments mentioned include at least 3 months of data.

In the second experiment, beta" alumina, which can take up cations such as deuterium, was used in place of D_2O, and both electrodes were made of Pd. Potential advantages of the solid electrolyte include a large overpotential, a potentially more convenient search for fusion products [such as tritium] due to elimination of the liquid phase, and higher sensitivity for excess heat measurements since the heat capacity for the system is much smaller (alumina is an insulator, so larger changes should be seen by a thermocouple in contact with the Pd).

Porous Pd electrodes 100 micrometers thick (created by baking on organometallic Pd) were loaded with D_2 at 1 atm. 20 V was applied (mostly to overcome the high resistance of the alumina). A temperature of approximately 250 C was used in order to attain reasonable ionic conductivity in the alumina.

Bursts of neutron emission several times the background count rate of 0.02/sec were measured. No excess heat (above that involved in the absorption of the deuterium) was seen, but the sensitivity of the heat measurements was still low -- the 0.1 C detection limit for heat would correspond to a much greater 10^{-10} fusions/sec/d-d pair.

In the discussion of stress-induced deuterium diffusion, it was suggested that when one side of a Pd sample is exposed to D_2, the expansion of the lattice on that side due to the hydriding can aid the diffusion.

In the following discussion, it was pointed out that the voltage used in the solid state electrolysis experiment was several times the decay voltage of the alumina, but the low current measured (20 mA) suggested that decomposition of the alumina was not in fact occurring.

CANADA - ION IMPLANTATION

J.S.C. McKee, G.R. Smith, C.B. Kwok, H.L. Johnston, M.S. Mathur, J.K. Mayer, A. Mirzai, Y.H. Yeo, K.S. Sharma and G. Williams (Univ of Manitoba, Canada), "Neutron Emission From Low Energy Deuteron Injection of Deuteron-Implanted Metal Foils (Pd, Ti and In)", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

In examination of the possibility of observing D-D fusion reactions at or near room temperature, our group at

Manitoba has searched for an enhancement in the neutron production rate resulting from stopping deuterons interacting with implanted deuterons in a metal matrix (Durocher, Can. J. Phys. 67 p 624, 1989). This non-equilibrium process was selected as an alternative to electrolysis as a means of injecting the material. The deuterons were implanted into the metal matrix by a small high current accelerator which accelerated a mixed beam of D^+ of energy 60 keV and molecular D_2^+ which upon dissociation at the surface of the metal yields two 30 keV D^+ ions. The precise composition of the beam was unknown. The presence of neutrons was registered continuously during the experimental runs. Scintillation light was detected as the neutrons transferred a portion of their energy to protons in a large plastic scintillator detector. Anomalous occurrences were observed during the operation of the experiments, in the form of sudden increases in the observed neutron detection rates. We undertook to repeat the experiment under more controlled conditions, with the intent of resolving to our satisfaction whether anomalous neutron production was actually occurring. In addition, an attempt to measure X-ray production within the target metal was made. The build up of deuterons in the metal matrix was such that where density of deuterons in a commercially available TiD target would be expected to be on the order of 4×10^{22} cm^{-3}, our implantation scheme resulted in deuteron densities up to 2×10^{25} cm^{-3} in the matrix. We argue that the loss of deuterons from the matrix will be small compared to build up rates. The results of our 1989 experiment will be compared with theory and results of a more recent one (July 1990), currently under analysis. Funding has recently been obtained from our local electric utility, Manitoba Hydro, for the production of analyzed beams of D^o, D^+ and D_2^+ for future implantation experiments. Work in this area is now under way.

COMMENTS

[In this presentation by Dr. McKee, an ion implantation experiment (which it was indicated might or might not prove related to cold fusion) reproducibly generated large fluxes of fast neutrons ("as though they are going out of style"). Ed.]

Ion implantation was selected because of its ability to provide an alternative to electrolysis as a nonequilibrium process for injecting large amounts of deuterium into metals. The beam current was 100 microamps, corresponding to a D_2^+ flux of 10^{16}/second, and the area illuminated was 1 cm^2. A bombardment length of 24 hours was used for Pd, and 9 hours for Ti; the estimated number of particles implanted in the Pd was 10^{21}. Thus, very high densities could potentially have been reached in the top micron. (Calculated ranges of D_2^+ and D^+ at 60 KeV are 0.42 and 0.56 microns; it is expected that most would stop in the last 0.1 micron of the range. Thus, local concentrations well above the solubility are possible.)

Neutrons were measured using an NE102 plastic scintillator viewed by 2 photomultiplier tubes; coincidence of signals on both was required, and the threshold was set high enough to further minimize background counting rates. It was noted that a large amount of background data on this detector was available since the detector is normally left on, and that the background has been shown not to vary significantly. In addition, an intrinsic Ge detector was used to measure the Pd K-alpha and K-beta X-rays at 21.200 and 23.836 KeV, and a NaI counter was used to measure gamma radiation resulting from (n,gamma) reactions in an In block placed beneath the sample.

In the experiment, 2500-3000 neutrons/sec with energies of 1-1/2 to 5 MeV (significantly different from the energy distribution in the background) were seen. In Pd, neutron production increased 50% during the course of the run in an approximately linear fashion. In Ti, the rise in production was on the order of 10%. Final levels in Pd and Ti were closely similar.

The gamma radiation measured served as confirmation that the neutron counts were in fact due to a high flux of neutrons. After both the Pd and Ti experiments, it was found that the gamma activity of the In block decayed with a half-life of 4.51 hrs equal to that of the ^{115}In metastable state created by neutron activation, and the activity indicated that the neutron flux to which the In had been exposed was 2000/sec/cm^2 in the case of the Pd and 2500/sec/cm^2 in the case of the Ti (consistent with the neutron counting rates measured). In addition, a carbon layer placed between the Pd and In, which would have stopped charged particles, had no effect on the activation.

SEM (Scanning Electron Microscope) photos of implanted and unimplanted samples showed the development of circular holes with diameters just under 2 microns during the implantation process.

Dr. McKee noted that the rates in such a "tepid fusion" experiment seemed higher than expected on the basis of high-energy d-d fusion data, and that the time variation seemed interesting. However, as the hot fusion cross-section increases exponentially between 30 and 60 KeV, planned experiments to determine the proportion of D^+ in the beam are important in establishing the magnitude of the discrepancy between the observed and expected rates.

In the subsequent discussion, Dr. Wolf of Texas A&M suggested pulsing the beam to distinguish between the production of delayed and prompt neutrons. It was suggested that the observed increases in neutron emission with time could be related to increases in the loading. It was indicated that the ion implanter was less stable at ion energies below 60 KeV, but that it should nevertheless be possible to use lower energies in subsequent experiments.

Dr. Srinivasan of BARC, India noted a very similar experiment performed at the IGCAR lab (Indira Gandhi Centre for Atomic Research) in India, in which reproducible variations also occurred over longer times. A similar experiment at the Kharkov Academy of Sciences in the USSR using a 25 KeV energy was also noted; in addition, after the bombardment the sample was unloaded by heating in a vacuum, and bursts of neutron emission were also seen at two temperatures during this process. This was therefore suggested as another useful adjunct to future experiments.

LOS ALAMOS - REPRODUCIBLE BURSTS FROM Ti

H.O. Menlove, T.N. Claytor, M.A. Paciotti, D.N. Tuggle (Los Alamos National Laboratory) and S.E. Jones (Brigham Young U), "Reproducible Neutron Emission Measurements From Ti Metal in Pressurized D_2 Gas", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

During the past year, we have measured neutron emission from samples of titanium (Ti) metal and sponge in pressurized D_2 gas. Beginning in January 1990, we improved our sample preparation procedure and our detector sensitivity level so that the neutron emission measurements are now reproducible. We have measured excess neutron emission from all of our last eight samples using our high-sensitivity neutron detectors. The improved sensitivity in our new detector system was obtained by using low radioactive background stainless-steel tubes, a small detector volume with high efficiency, and additional cosmic-ray shielding. Our most sensitive detector consists of two independent segments making up inner and outer rings of ^{3}He tubes. The inner detector has nine ^{3}He tubes (2.5 by 30 cm), and the outer detector has forty-two ^{3}He tubes (2.5 by 50 cm). The combined total efficiency is 44%. In addition to inner and outer ring segments, we have three separate detector systems operating in parallel control experiments to monitor environmental change. We have measured neutron bursts from a variety of samples containing Ti metal and D_2 gas. The low-multiplicity bursts emitting from 2-10 n occur much more frequently than the higher multiplicity bursts. By measuring high-mass samples (300 g Ti) over several weeks with several liquid nitrogen temperature cycles, we have detected excess neutron emission from all of the samples with a significance level of 3 to 12 sigma. Blank samples containing Ti plus H_2 gas or D_2O have given no excess neutron emission. Details concerning the detectors, experimental procedures, and neutron emission results will be presented.

COMMENTS

[Dr. Menlove's presentation described high-sensitivity neutron measurements in Ti gas-loading experiments. Sample preparation was discussed in the presentation by Dr. Paciotti. Ed.]

Detectors:

A number of major points were made regarding the neutron detector design: First, in order to achieve the especially high efficiency quoted, and thus allow very low-level counting, the detector has a 4-pi geometry (i.e. the sample is in a central well, completely surrounded), and contains a large number of ^{3}He tubes (with polyethylene moderator). Second, the detector is portable, so that they have been able to use it in underground sites in the US, Italy and China, in order to greatly reduce the cosmic-ray background counting rates. Third, considerable effort has been made to protect against noise. For example, the amplifiers are protected with desiccant, and they are also protected against electromagnetic interference (RF pickup), which are the 2 most common sources of interference with ^{3}He counters. (Moisture tends to cause bursts due to high voltage breakdown.) A "veto" counter on the same power line (but with Cd shielding and without moderator, rendering the sensitivity to actual neutrons very low) also allows spurious counts arising from line noise to be ignored. The external ring of ^{3}He tubes added, which has separate electronics and readout, also helps check for spurious counts. (However, it has been found that this ring is far enough from the cell that the signal from the cell is typically buried in the cosmic ray spallation background.) Fifth, the amplifier signal is sent to a shift register to allow time-correlated as well as singles counts; it was stated that without the much lower background in the coincidence mode it would not have been possible to demonstrate the small increases in neutron emission rate cited in the abstract. An approximately 100 microsecond gate is used; if 2 counts occur within this, a correlated count is registered. Values for the background count rate in this mode as low as 0.68/hour were reported to have been achieved using added shielding in underground sites. In addition, statistical analysis can be performed on the number of coincidence counts within 32 microseconds and 128 microseconds (to demonstrate that the counter is behaving reasonably) when the number of counts is sufficiently high. Sixth, background counters are located nearby and operate simultaneously. Seventh, samples could be moved from one detector system to another while they were active (i.e. if count rates for the sample were, say, 5 standard deviations above background, moving the sample to an alternate detector caused the first detector's count rate to drop to normal and that of the new detector to rise to a comparably high level.)

Results:

Background count rates showed the expected Poisson distribution when averaged over 24-hour periods, although deviations of many standard deviations from this distribution were observed over short periods due to cosmic ray events. With only one possible exception, the 3 to 12 sigma (standard deviation) increases in the random neutron counting rates of the most recent 9 samples represent long-term averages over periods of half a week to 6 weeks, and no comparable increases in the background during this period exceeded 2 sigma. Also, by rotating active and control samples between detectors, it has been possible to show that the random neutron emission did in fact appear to originate from the cell. In addition to this, rare burst events corresponding to up to several thousand correlated counts have been observed. As noted previously, these show a correlation with the temperature cycling, with the greatest frequency within 20 degrees of -30 C, similar to the pattern seen by Izumida (Hitachi, Japan), although the number of bursts for a given cycle can vary from zero to several. Also, the fraction of bursts which are of particularly high multiplicity is considerably higher at -30 C than at room temperature.

Future plans:

In addition to experiments with tritium loading, further material characterization and neutron energy spectrum measurements are contemplated.

STANFORD - EXPERIMENTAL ERRORS

W.E. Meyerhof (Stanford Univ.), "Statistical Analysis of a `Cold Fusion' Experiment", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Yagi et al recently have claimed that neutrons from the D + D reaction are emitted in Ti and in SiO_2 systems in which D_2 is trapped at approximately 1 atm at liquid nitrogen temperature. A statistical analysis of the data shows that the background counts observed over 58 time intervals do not follow the expected Poisson distribution. This would invalidate the interpretation of the results.

COMMENTS

[This study involved a statistical analysis to disprove the low-level neutron production reported in a previously published cold fusion experiment. Ed.]

The key point was that while the mean background was 3 counts per 1000-second interval, the graph presented indicated that no time interval had over 5 counts; given the number of data points, a chi-squared test indicated a very low probability that random chance could have resulted in such a deviation from the normal Poisson distribution (a probability distribution in which the probability of i counts occurring is given by $P(i)= mu^i X e^{-mu} /i!$, where mu is the mean). In contrast, the results for the sample fit the Poisson distribution much better (within 5-95% confidence limits).

It was thus pointed out to be important that statistical analyses be performed in experiments in which low count rates are involved, in order to help demonstrate that the equipment is functioning properly.

In the discussion, it was pointed out by Dr. Srinivasan of BARC, India that the opposite deviation from a Poisson distribution (a greater-than-expected occurrence of higher count rate values) may occur in background counts due to cosmic ray spallation. [In such a test, either the number of occurrences of i counts or the log of this number is plotted versus i. Ed.]

[Another discussion of misleading data was given in the presentation by Dr. Anderson. Ed.]

WEBER STATE - CHARGING & THERMAL DATA

Jerry R. Montgomery, Rondo N. Jeffery, Farhang Amiri, and D. Jack Adams (Weber State College, Utah), "Correlated Nuclear and Thermal Measurements In D/Pd And H/Pd Systems", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Gas loaded D/Pd and H/Pd rods (1 mm dia.) were used to investigate correlated thermal and nuclear effects. Simultaneous measurements were made of gas pressure, electric current, voltage drops, wire and chamber temperatures, and neutrons. D/Pd and H/Pd ratios were monitored by resistance changes in wire segments. Two deuterium runs (totalling 3000+ hours), one hydrogen run (nearly 1000 hours), and background runs (2000+ hours) have been completed. Two neutron bursts were recorded in the first deuterium experiment. No bursts, but periods of increased activity, were observed in the second deuterium run. No increased activity was observed in the hydrogen experiment. Accurate agreement with Poisson counting statistics was found in the background

and hydrogen runs. Neutron bursts observed in the first deuterium run exceeded, by several orders of magnitude, the Poisson prediction. A slight resistance increase in one wire segment was observed during one of the neutron bursts. No simultaneous increase in wire temperature was observed. Several potential triggering mechanisms were tried. Further experiments will examine an observed possible resonance-like effect.

COMMENTS

[The goal of the Pd gas-loading experiment described by Dr. Montgomery, which unfortunately gave only very low neutron production, was to simultaneously measure and control as many parameters as possible. Ed.]

A current varying between 2 A and 4 A on a 1-minute cycle was passed through the rods, and samples were periodically unloaded and reloaded. Other tests involved varying the current pulses and direction, switching the current on and off, changing the pressure, fast and slow neutron bombardment, mechanical strain and impact.

Background neutron count rates were on the order of 10/hour. No excess neutrons were seen during the first few months. After the start of the loading/unloading cycles and changes in the current density, two bursts of 8 counts in 15 second intervals were seen, possibly associated with changes in the current. Slight changes in the temperature, pressure, and resistivity coincident with one burst were also reported. As indicated in the abstract, no such bursts were seen in an equal (3000 hour) length of time during the control experiments, and plots of the log of the number of occurrences of i counts versus i confirmed that the bursts represented the only significant deviations from the Poisson distribution in either data set. The increased neutron activity in the other rod occurred over a 10-day period.

Resistance measurements were also used to monitor the charging of different segments of the rod; these responded at different rates and reached different final values. Loading appeared to be faster the second time than the first.

Future plans include the use of different Pd samples and Ti, use of more efficient neutron detectors and addition of charged particle detectors.

During the subsequent discussion, it was noted that an increase in the count rate would have been expected on Sept. 29, 1989, reflecting a 2-day, 5-fold worldwide increase in the neutron background due to record levels of solar activity.

LOS ALAMOS - Ti SAMPLE PREPARATION

M.A. Paciotti, H.R. Maltrud, H.O. Menlove, O.M. Rivera (Los Alamos National Laboratory) and S.E. Jones (Brigham Young U), "Sample Preparation for Reproducible Neutron Bursts", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

A procedure is given that reproducibly induces neutron bursts (<50 microsecond duration) from titanium exposed to deuterium gas. Since May 1989, 13 pressure cylinders filled with titanium, titanium alloy, or titanium sponge have been prepared and examined for neutron emission. Repeatability is claimed on the basis of positive response from 11 of the 13 samples. Among the first 5 samples, the 3 with positive responses gave 2-4 bursts of emitted neutron multiplicity greater than 20 or 30. Such occurrences are rare in dummy samples or H_2 "controls". All of the last 8 samples responded positively with neutron excesses three or more standard deviations above the cosmic ray background. "Reproducibility" in this group was established by summing over days the low multiplicity bursts with source strength of 2-10 neutrons. The high multiplicity bursts have been elusive in these eight samples; only a few large bursts were observed. Our objective is that every sample be productive so that planned tests with D - T (or H_2) will be meaningful. Even though we cannot predict when large bursts will occur, consistent observation of smaller bursts is attainable. Samples are degreased with methylene chloride, methanol, and water before pumping and flushing with purified H_2 or D_2 at temperatures between 120 C and 220 C. In all but one sample, the titanium began absorbing gas during flushing or after the first thermal cycle to 75 K. The technique for introduction of the clean D_2 has evolved, and the changes could account for reduced probability for larger bursts. We list some empirical rules that help predict why some samples yield more neutrons than others.

COMMENTS

[Dr. Paciotti described the preparation of the Ti gas-loading samples in the preceding talk by Dr. Menlove. Ed.]

The procedure, as described in the abstract, required 2 days. Oil-free pumps were used. Up to 10 cycles of purging were performed, and continued until the final temperature was approached, in order to reach into cracks not easily pumped clean. Hydriding was avoided during the purging stage. Gas pressures used were up to 1000 psi. For the final hydriding, a known amount of gas was introduced in order to give an average composition of

$TiD_{.02-.05}$ after the first cycle, and a pressure transducer was used to measure the actual gas uptake. The alloys used were commercially pure Ti, Ti alloyed with 6%Al and 4%V, and Ti alloyed with 6%Al, 6%V and 2%Sn. (The latter is referred to as Ti-6-6-2 in other abstracts. Possibly significant differences noted due to alloy composition include large changes in the martensitic shear induced by loading of alloys with different V contents.)

The D_2 uptake effectively stopped at 75 K (approximately -200 C); although the solubility increases, diffusion becomes very slow. On warming, active Ti surfaces begin to absorb deuterium at approx -50 to -30 C. Gas uptake was greatly increased by the initial cycling down to 75 K.

Poor performance appeared to occur if the D_2 is introduced so fast that the Ti heats (2 nonperformers and one low performer resulted), if the gas is introduced at room temperature (2 or 3 nonperformers resulted), or if the sample is deuterated to saturation. Also, samples eventually appear to wear out -- they cease to absorb gas, bursts (at least low-level ones) stop, and chips become brittle and crumble. A control sample not warmed up after saturation also never gave a response, indicating that the temperature change is necessary.

A problem was encountered with the H_2 controls: the gas to which a control which counted 4 sigma above background for 3-4 days and a previous control were exposed actually contained 1% D_2 as a result of the storage tank having previously been exposed to D_2. (When the same control sample was exposed to pure D_2, it counted up to 9 sigma above background over 24 hrs, but this was not a vast increase.) It was noted that the Ti may concentrate the D_2; on 3 occasions it was observed to absorb more easily than the H_2.

As a $TiD_{0.25}$ sample gave as good a result as a $TiD_{1.7}$ sample, it is possible that the amount of gas being used is still greater than necessary.

Other future plans include resolving the questions raised by the last control and attempting to better understand the separation factors. A reproducible effect should also allow further study of the timing of bursts (preferred temperature), determination of how much gas is really necessary, and attempts to create larger bursts. (Their fifth sample, which had a deliberately oxided surface, suggested that this may be conducive to larger bursts.)

Given the fact that the samples contain a number of individual chips yet neutron production occurs in bursts, it seems likely that only a small fraction of the chips are actually active.

ITALY - HIGH EFFICIENCY DETECTOR

A. De Ninno, C. Pontorieri, F. Scaramuzzi, P. Zeppa (ENEA, Frascati, Italy), "Emission of Neutron Bursts From A Titanium-Deuterium Gas System in a High-Efficiency Low-Background Experimental Setup", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

The emission of neutrons from a titanium-deuterium gas system has been detected in experiments performed in the Spring of 1989. One of the most striking features was the structure in bursts (duration of about 100 microsec) of the neutron emission. Using a detection system proposed by a Los Alamos group (H. Menlove, as presented at the First Annual Conference on Cold Fusion), suitable to analyze the structure in bursts of the emission, a preliminary set of measurements has been performed with satisfactory results (as presented at the First Annual Conference on Cold Fusion). A better tailored detector is now in use, and measurements in a low neutron background setup are being started. The first results of this experiment will be presented.

COMMENTS

[Dr. Scaramuzzi's presentation described small neutron bursts observed in Frascati Ti gas-loading experiments using a new extremely-low-background neutron detector. Ed.]

Although gas-loading experiments were chosen because they were judged to entail fewer complexities than electrolysis, a lack of reproducibility was seen in the early Frascati experiments, as presented at the Santa Fe and Salt Lake conferences. Thus, followup experiments with a new, high-efficiency Jomar neutron detector (optimized for such experiments) have been performed in low-background underground sites in an attempt to establish their correlation with thermodynamic parameters (triggers) for neutron bursts.

The sample well is surrounded by an inner ring of 20 ^3He tubes, and an outer ring of 8 which is registered separately. Four additional ^3He tubes (without moderator) on the same power line are used as veto counters to minimize spurious counts. Despite the larger detector area, the background count rates due to cosmic rays were reduced to 10^{-3}/sec (dropping off rapidly with energy) by using the Gran Sasso facility (1600 m underground). In addition, the new ^3He counter, constructed with stainless steel rather than Al tubes, has a considerably lower intrinsic background. Finally, correlated counts are used to further improve the signal-to-noise ratio to the point at which essentially every event can now be considered real. (The background coincidence count rate, which had averaged 5 per 1000 seconds in the Frascati laboratory, dropped to zero counts in 2-3 weeks in Gran Sasso; in comparison, the singles rate was 0.02/second.)

Comparison of the signals from the inner and outer rings can also be used as another indication that the events seen came predominantly from inside the cell. (In a test in which a Cf source was placed in the well, the ratio of counts in the inner and outer rings was 90, versus 2.5 for the background.)

Preliminary data showed a significantly greater number of occurrences of small bursts (approximately 15-32 correlated counts) in TiD than in a TiH control, although the total number of such episodes is still small.

A timing mechanism is also being developed which will record the time of each count in a burst to within 0.05 microseconds.

[Dr. Scaramuzzi also mentioned two experiments by other groups which he found quite suggestive: In work done by Dr. Kharkov at the Institute of Science in the USSR, deuterium ions were implanted into Ti or Pd targets at 100 K, and the samples were then allowed to warm up. Neutron emission was reported at approximately -30 to -50 C (and possibly again at 1000 K), along with tritons, ^{3}He and protons of the proper energy for d-d fusion. The experiment seemed quite reproducible, and the calculated loading was high (up to TiD_5 and $PdD_{1.6}$). Also, in a plasma focus experiment reported by Dr. Srinivasan (BARC, India), high tritium levels were found after implantation, and high D concentrations were again attained.]

GERMANY - Pd ELECTROLYSIS

M. Bittner, A. Meister, D. Ohms, E. Paffrath, D. Rahner, R. Schwierz, D. Seeliger, K. Wiesener and P. Wustner (Tech. U of Dresden, Germany), "Evidence for the Production of DD-Fusion Neutrons During Electrolytic Infusion of Deuterons into a Palladium Cylinder", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT (Paper not presented)
A long-duration experiment for the observation of dd-fusion neutrons emanating from a massive palladium cylinder is described. The experimental results are discussed in the frame of a plasma-like model of fusion in condensed matter, resulting in calculated fusion rates of $\text{lambda}_{dd} = (1.19 \pm 0.15) \times 10^{-44}$ per sec.

JAPAN - PULSED ELECTROLYSIS

A. Takahashi, T. Takeuchi, T. Iida (Osaka U, Japan), and M. Watanabe (Matsushita Electric Industrial Co., Japan), "Neutron Spectra from D_2O-Pd Cells with Pulse Electrolysis", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

To confirm "cold fusion phenomena", a series of pulse electrolysis experiments has been carried out using D_2O-Pd cells. Biased-pulse operation of electrolysis current was adopted, in order to possibly enhance the transient D-D fusion probability under virtual electron screening effects in the PdD_x lattice, and to ascertain the correlation between fusion events (neutron counts) and electrolysis. Typical operation conditions for stronger (a) and weaker (b) current regions are: [currents] Ia/Ib = 1.1-1.4 amp/0.2 amp and [times] Ta/Tb = 8.5 min/8.5 min.

For Pd cathodes, a 10 mm dia, 5 mm thick Pd metal [disk] (99.5% Pd, 0.5% Ag) and a 10 mm diam 30 mm long pure Pd metal (cold-worked, 99.99% Pd) [rod] were used. Experiments have been carried out for about 4 months, changing the biased-pulse conditions, LiOD density (0.2-0.6 mol/l) and Pd samples. Neutrons are measured mainly by an NE213 recoil proton scintillation detector (5 inch diam 2 inch thick), rejecting gamma-ray signals and other noise signals by the pulse shape discrimination circuit. Pulse height spectra of recoil protons by H(n,n) scattering, time history of neutron count rates and time-correlation between neutron counts and biased-pulse operation are always monitored. The time history of neutron counts by a He-3 thermal neutron detector (5 inch diam spherical, 5 atom, with 5 cm thick polyethylene moderator) was additionally used to make cross checks of excess neutron counts. Neutron spectra and count rates of the background were taken by stopping electrolysis (and taking out Pd cathode); correction for the variation of cosmic neutron counts was done.

After several weeks of operation, we found meaningful excess neutron counts and we could obtain corresponding fast neutron spectra, for "certain" experimental conditions. Clear 2.45 MeV neutron components were observed in wide time regions repeatedly. The most mysterious results are that the observed neutron spectra sometime have "higher energy components" in the 3-7 MeV region; these were observed for both Pd samples. It was confirmed that the higher energy component was neither due to the multiple neutron detection nor due to the contamination of gamma and other noise events. **A possible explanation at the moment is very bold;** 3D fusion reactions would occur to make byproducts of these higher energy neutrons in the slowing down process of 15.9 MeV deuterons of

primary products. The hypothetically proposed excitation screening model may support the possibility of 3D fusion. An amount of tritium would be produced by the 3D reaction.

COMMENTS

[This presentation by Dr. Takahashi reports excess fast neutron production in a Pd electrolysis experiment at not only 2.45 MeV (as expected from conventional d-d fusion) but also higher energies. Ed.]

The overall neutron count rates in this experiment increased from an initial rate of 400 counts per 3 hours to approximately 550 per 3 hours after 500 hours of electrolysis. It is very unfortunate that the only simultaneous background monitoring performed during the experiment was done in Tokyo rather than in the lab at Osaka. After this background was subtracted, the derivative of the spectrum was taken in order to look at differences in the structure of the two spectra. [This method appears to have helped in identifying the numbers and energies of the excess neutrons; however, it is unclear how sensitive this technique would be to typical background variations, compared with other methods. Ed.]

Although two portions of the neutron energy spectrum appeared to have increased, graphs indicated that the peak near 2.5 MeV was considerably sharper while the higher-energy peak was somewhat flat in shape between 4 and 6 MeV. In addition, it is interesting that in many cases first one and then the other peak would appear -- for example, in the first 300 hours only the higher-energy peaks were seen.

JAPAN - BEST DETECTOR AVAILABLE

Y. Totsuka (U of Tokyo, Japan), "Kamioka Experiments"

COMMENTS

[This presentation described the availability to the scientific community of possibly the most sensitive neutron detector in the world. No abstract was available. Ed.]

The detector consists of 4500 tons of pure water viewed by a large array of phototubes, 1000 m underground in the Kamioka mine in Japan. Neutrons are detected by the observation (through the Compton process) of gamma radiation produced by (n,gamma) neutron-capture reactions which occur after the neutrons have been moderated. If the gamma energies are above 7 MeV (for example, capture by Ni gives a 9 MeV gamma), the individual gamma photons can be readily measured; the background at 7-8 MeV, for example, is 0.2 to 0.03 counts per 10 hours. (This detector is normally operated at a 5 MeV threshold; this implies the signal should be seen by over 20 of the photomultipliers in < 100 nsec.) The photomultiplier array also allows the position and direction of the gamma ray to be measured.

The maximum manageable burst is 30 events in 1 microsecond, or 100 in 100 microseconds. Because of the low background, this detector is extremely well suited for measuring low random or burst production of neutrons.

Dr. Totsuka indicated that researchers could request permission to use the detector for measuring neutron production by their cells. It was later indicated that Dr. Jones of BYU and Dr. Worledge of EPRI intended to do so.

TEXAS A&M - EXPERIMENTS TO DATE

Kevin Wolf (Texas A&M), "Neutron Emission Studies"

COMMENTS

[In this presentation, Dr. Wolf summarized the scope of the neutron experiments performed to date. No abstract was available. Ed.]

The experiments included well over 100 Pd electrolytic cells (including 9 of the Jones type) as well as 5 Ti gas-loading experiments (1000 psi D_2, 3 using RF induction) and 4 Wada-type spark-gap experiments with Pd. (Enhancement with neutron and gamma bombardment was also tried.) It was noted that of these experiments, it was the electrolytic cells with 6 mm X 10 cm Pd cathodes and Ni anodes (containing 100 times as much Pd as in the early 1 mm cells) which gave the notable results.

An NE-213 neutron detector was described which contained a particularly large phototube, was optimized to avoid light traps, and used pulse discriminator electronics to accumulate data in 10 microsecond blocks. The detector was surrounded by a foot of paraffin and by very large cosmic ray veto counters; a second detector was used to simultaneously either view the same cell or measure the cosmic ray background under the shielding. Compact electrolytic cells were used to give better detection efficiency (i.e. the detector would thus cover a larger solid angle around the cell). The efficiency was approximately 5%. Measurements were performed both at the Texas A&M Cyclotron Institute and in the Black Cloud Mine. The background count rate in the mine was 0.5/minute.

Count rates for approximately half of the Pd electrolytic cells run (for several days at increasing voltage) in the mine were high, for periods of up to 10 hours, typically starting within 2-5 hours. An example was given of a cell which gave 1.8-2.2 counts/min (7 sigma above background) for 4 hours; this was well above the (up to 3 sigma) variation in the background over such a period, and a second detector seeing an equal amount of Pd and D_2O at the same time gave only the background count rate.

An energy spectrum (up to 50 MeV) was obtained; comparison of the results with Monte Carlo simulations indicated the results were not grossly inconsistent with 2.5 MeV neutrons, although some harder neutrons may also have been present. A ^{6}Li detector was also used to check for low energy neutrons; these were not seen.

JAPAN - LARGE BURSTS - SURFACE COATING

Eiichi Yamaguchi and Takashi Nishioka (NTT Basic Res. Labs., Tokyo, Japan), "Nuclear Fusion Induced by the Controlled Out-Transport of Deuterons in Palladium", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

We present a new technique for enhancing anomalous nuclear effects in deuteron/solid systems. This method makes use of the production of D accumulation layers at Pd surfaces, due to the controlled out-transport of D-atoms, on Pd:D systems set in a vacuum chamber. By using this "vacuum" technique, we observed:

1. Gigantic neutron bursts of 1-2 x 10^6 neutrons per sec from Pd:D plates,

2. An explosive release of D_2 gas,

3. Uniform biaxial bending of all the samples, and

4. Excess heat evolution, at the same time.

We also observed the phenomena 2,3,& 4 on Pd:H systems with this method. This is the first evidence that the excess heat production cannot be caused by D-D reactions.

COMMENTS

[The experiment described by Dr. Yamaguchi is notable for the very large neutron bursts created under controllable nonequilibrium conditions. The experiment involved the creation of an accumulation layer of deuterium during unloading (high deuterium flux) in a Pd gas-loading experiment through the use of surface coatings. Ed.]

The effect of such a barrier in creating locally high concentrations next to it under conditions during outgassing of the metal was expected to be analogous to the electron accumulation layer in metal-insulator-semiconductor sandwiches.

(It was noted that the initial impetus for such work involving nonequilibrium conditions was calculations by Sun and Tomanek [Phys. Rev. Letters 63 p 59, 1989] and by Wang, Louie and Cohen [PRB 40 p 5822, 1989] of the large separations expected between two hydrogens occupying the same site in a Pd lattice (0.95 to 3.8 A, versus 0.74 A in H_2) if only equilibrium conditions are considered. As in the case of many other groups, a gas-loading rather than electrolytic system was chosen because of its apparently lesser complexity.)

In the experiment, a <10 nm layer of Mn and O is deposited on one side of a pure Pd film, and the film is loaded with 400 torr of D_2 gas for 24 hrs. A >100 nm thick Au film is then deposited on the other side of the film, and the sample is placed in a vacuum. After approximately 3 hours, a neutron burst lasting 2-3 seconds was measured using ^{3}He detectors, gas release (predominantly mass 4 with some mass 3) was measured by mass spectrometry, and plastic deformation was seen in which the sample flexed, with the Au side becoming concave and the Mn oxide side convex. The accumulation layer and gas release were indicated to occur on the Mn oxide side when the sample was placed in a vacuum. In addition, a surface temperature of over 700 C was inferred to have been reached, based on subsequent SEM examination of the Au side in which the gold appeared to have been completely alloyed with the Pd.

The plastic deformation was observed to be rapid, taking less than 1 minute. The temperature increase was inferred to precede an increase in the mass 3 peak in the gas; however, as a decrease in the mass 2 peak was also observed, it was suggested that the mass 3 peak was more likely due to H_3 rather than tritium.

As noted, only the neutron production did not occur in the hydrogen-loaded controls. When a deuterated sample was cycled a second time, the neutron burst was smaller, 0.6-0.9X10^6 neutrons/second.

More recent experiments have included the use of current injection (with a DC pulse applied through a tungsten needle), addition of a second (independent) neutron detector, and addition of two charged particle detection systems (which will in the future be able to determine energy spectra).

A cooperative cycle of positive feedback is suggested in which deuterium accumulation at the interface produces a layer with a large lattice constant, leading to strain, which in turn enhances deuterium migration, until eventually plastic deformation occurs. It is possible that rapid phase transitions/lattice rearrangement, defect formation, etc. associated with the deformation, and/or a decrease in the number of optimal D sites during this process, aids in the fusion process. Possible anomalous ionization during the gas release was also mentioned.

In the subsequent discussion, it was noted that several other oxides and nitrides have also been tried, with similar results.

[Data comparing the amount of heat produced from similar Pd:D and Pd:H experiments was not available. However, some heat in the PdD samples would have resulted from the nuclear reactions; the amount will depend on the energy yield of the neutron-producing reaction and also on the energy released by other nuclear reactions which do not generate neutrons. Given previous branching ratio data, the amount of such heat could be large; thus followup calorimetry work could be of considerable interest. Ed.]

CHINA - GAS LOADED Ti

He Jianyu, Zhu Rongbao, Wang Xiaozhong, Lu Feng, Luo Longjun, Liu Hengjun, Jiang Jincai, Tian Baosheng, Chen Guoan, Yuan Yuan, Dong Baiting, Yang Liucheng, Qiao Shengzhong, Yi Guoan, Guo Hua, and Ding Dazhao (China Inst. of Atomic Energy, Beijing), "Experimental Study on Anomalous Neutron Production in Deuterium/Solid System", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

A series of experiments on both D_2O electrolysis and thermal cycling of deuterium absorbed Ti turnings has been designed to examine the anomalous phenomena in Deuterium/Solid Systems. A neutron detector containing 16 BF_3 tubes with a detection limit of 0.38 n/s for two-hour counting was used for electrolysis experiments. No neutron counting rate statistically higher than the detection limit was observed from Fleischmann & Pons type experiments. An HLNCC neutron detector equipped with 18 ^3He tubes and a JSR-11 shift register unit with a detection limit of 0.20 n/s for a two-hour run was employed to study the neutron burst signals in D_2 gas experiments. The experiment sequence was deliberately designed to distinguish the neutron burst from false signals, e.g. electronic noise pickup, cosmic rays and other sources of environmental background. Eight batches of dry fusion samples were tested, among them six batches with neutron burst signals which occurred roughly at the temperature between -100 C to near room temperature.

In the first four runs of a typical sample batch, seven neutron bursts were observed with neutron numbers from 15 to 482, which are 3 and 75 times, respectively, higher than the uncertainty of background. However, no bursts happened for H_2 dummy samples running in-between and afterwards and for sample batch after certain runs.

COMMENTS

[This presentation by Dr. Zhu described neutron bursts observed during a Ti gas-loading experiment, similar to those reported by other groups. Ed.]

In the second-generation experiments described (involving 270 g of Ti and 90 atm D_2), the background level was greatly reduced by various means. Power line noise was eliminated by using a battery, cosmic rays background was greatly reduced (to $7X10^{-5}$ counts/sec) by using correlated counts (128 microsecond window), operating at a depth of 580 m in a mine, and using additional paraffin and Cd shielding, and humidity and temperature were controlled to prevent discharges in the counter. Also, about as much time was spent in counting dummy samples and background as samples (although the background was not counted simultaneously). The efficiency of the detector in the single-count mode was 20%.

It was found that samples which ceased to be active could be reactivated, but with decreasing effect, by degassing and reloading.

(The BF_3 detector in paraffin moderator which was used in the electrolysis experiments also mentioned had an efficiency of 6.8% and a relatively high background of 0.3 counts/second.)

In the future, a multidetector system and energy measurements are desired.

D. CHARGED PARTICLE DETECTION

COLORADO - GAS LOADED Ti

F.E. Cecil, H. Liu, D. Beddingfield (Colorado School of Mines) and C. Galovich (U of N. Colorado), "Observation of Charged Particle Bursts From Deuterium Loaded Ti Thin Foils", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Observations of intense bursts of charged particles (up to about 10 per sec.) using Si surface barrier detectors from deuterium loaded Ti alloy thin metal foils which had been temperature cycled to -180 C and subjected to moderately

high current densities (100 mA/cm^2) will be presented. Particle energies from about 1 to 10 MeV have been measured. Preliminary efforts at particle identification suggest that some of the particles are tritons with energies up to 4.2 MeV. Analogous bursts were not observed in similarly prepared hydrogen loaded foils. Efforts to exclude possible artifactual sources of these observations will be discussed.

COMMENTS

[Charged particle count rates on the order of several hundred per second in gas-loaded Ti, possibly including unusually high-energy tritons, were reported by Dr. Cecil. (Preliminary experiments reported at the Santa Fe conference had been negative.) Ed.]

Ti 6-6-2 samples from Dr. Jones were vacuum annealed for 2 hours at 700 C, then loaded with D_2 gas (2 atm) for 1 hour at 700 C. (A 2.5-3.5% mass change was inferred to indicate a composition near TiD.) The samples were then placed on a cold finger in the counting chamber (approximately 1 cm from the Si detector), to allow cooling with liquid nitrogen, current (from a battery) was applied, and the charged-particle energy spectrum was measured in 10-minute intervals. During this time the sample was cooled to -180 C in 40 minutes, then allowed to warm up after an additional 20 minutes, and counted an additional 20-25 hours; the temperature cycling was repeated 3-5 times. Controls included both unloaded Ti and Ti+H_2 samples. The detector energy calibration was checked with an Am source. The background counting rates were very low.

The sample gave a very clean energy spectrum, with count rates of several hundred per 5-minute interval. The changes in this spectrum with time appeared quite interesting: after 2 hours or more, the count rate above 1 MeV increased 2-3 orders of magnitude in a series of bursts, and the energy of the peaks typically increased as the temperature increased, suggesting a change in either the depth at which the particles were produced or the mechanism responsible. (In one calculation it was estimated that 3 MeV particles could lose up to 200 KeV of energy in the 3.5 mil thick foil, depending on the depth at which they were created). Also, during a series of bursts, the current was turned off; the counts persisted for 10-15 minutes before dying away, then reappeared after the current was restored, and died away a second time when the current was turned off again. Pulse shapes, as observed on the CRT, were reasonable.

A "poor man's particle identification system" was used to determine the types of particles responsible: half of the detector was covered with 6 micrometers of Al, and half with 19 micrometers, causing each peak in the original spectrum to be split into two peaks (since the energy loss of half of the particles would differ from that of the other half). This technique was also tested by examining the products of a ^{6}Li+D reaction; the 4.5 MeV triton signal was split into two peaks at 3.15 and 4.07 MeV as expected. The apparent energy loss rate of the particles from the sample, on the other hand, ranged between those of alpha particles and tritons. Similarly, when the detector voltage was turned off during 1 burst, the average gain decrease was 48%, versus 54% for 5.4 MeV alpha particles and 26% for 3 MeV protons produced during a similar test with an accelerator source.

Twenty-four bursts were recorded in 56 days (July 6 to September 10, 1990) from 12 of 26 samples, usually after 6-10 hours (i.e. as room temperature was approached). The burst durations varied from seconds up to approximately 200 minutes. Ten bursts occurred during the first temperature cycle, 8 during the second, 1 during the third and 4 during the fourth, suggesting significantly greater production during initial cycles.

No bursts occurred during the more than 1 week that the 12 TiH samples were run; the probability that such a difference in behavior could have occurred by chance was calculated as less than 2%.

As significant numbers of protons were not seen, the pattern did not appear to correspond to that expected for the d+d->p+t mechanism; also, there was no evidence of 24 MeV alphas or other high energy events (up to 30 MeV); in fact no counts above 14 MeV were seen. The failure to detect more than one main peak should thus place some constraints on possible 2-body and multibody theories.

The next phase, involving a new chamber which would allow energy determination on a particle by particle basis, has not yet yielded results.

NRL - ION BOMBARDMENT

George Chambers, Graham Hubler and Ken Grabowski (Naval Research Laboratory), "Search For Energetic Charged Particle Reaction Products During Deuterium Charging of Metal Lattices", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

An effort has been made to create cold fusion in thin films of titanium under low energy (300-1000 eV) deuterium ion bombardment in a vacuum chamber. Deuterium ions are produced by extraction from a plasma produced in a Microscience electron cyclotron resonance (ECR) source and by a Kaufmann ion source. The

sample is monitored during bombardment with a silicon particle detector in order to detect possible charged energetic reaction products. A variety of metallic foils, bulk samples, and vacuum evaporated thin films have been bombarded with deuterium ions at current densities ranging from 0.4 mA/cm^2 to 5 mA/cm^2 and at temperatures ranging from 80 K to 273 K. Charged particle spectra will be presented, including background and control experiments, along with information about particle identity and possible reaction models.

COMMENTS

[This presentation by Dr. Chambers described the production of particles tentatively identified as unusually high-energy tritons during ion implantation. Ed.]

This series of experiments began 1-1/2 years ago with negative results. Since then, a more advanced ion beam apparatus, using a detector with very high efficiency (including a high solid angle in viewing the sample) and low background (5 counts/day) has allowed sufficiently higher sensitivity to allow fusion rates on the Jones level to be examined.

Pure Ti, two Ti alloys (6-4 and 6-2-4-4), and pure Pd were used. Samples included both foils and 1-micrometer-thick films deposited on Ni foil. At the ion implantation energy used (300-350 eV for the ECR source, 1000 eV for the Kaufmann gun), the cross-section extrapolated from hot fusion data should be extremely small. Samples could be cooled to prevent thermal damage.

Pulse shapes were observed on a digital storage oscilloscope. It was found that spurious counts from beam-induced noise, microphonic noise, arcing and power line noise could be distinguished from actual signals using pulse shape and a veto counter on the same power line. As a further test, the energy shift occurring when the detector bias was switched off was measured.

Charged particles were measured at several standard deviations above background; bursts were also noted. This was in contrast to the behavior of the hydrogen-loaded controls. Particle energies were up to 5 MeV. The 3.5 MeV of energy deposited at zero bias was indicated to fit tritons best, rather than ^4He (4.3 MeV expected), ^3He (4.1 MeV expected), ^1H (1.9 MeV), or ^2H (3.0 MeV). Similarly, the change in the spectrum on interposition of a thick foil is consistent with the identification of the particles as tritons. However, the triton energies are much greater than those produced by the conventional d+d->t+p reaction (1.0 MeV). The inferred cross-section is at least on the order of 10^{-5} barns. (If only small areas are involved, as seems possible, the required cross-section could be much larger still.)

SAN FRANCISCO - ION BOMBARDMENT COATING

E. Lopez, B. Neuhauser (San Francisco State Univ.), F. Ziemba (Quantrad Corp), J. Jackson (IICO Corp.), E. Mapoles (Lawrence Livermore National Laboratory), J. McVittie (CIS, Stanford Univ.), and R. Powell (Varian Associates), "Search for Charged-Particle d-d Fusion Products in an Encapsulated Pd Thin Film', Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Stimulated by reports by Fleischmann and Pons and Jones et al. of nuclear fusion at room temperature, we attempted to look for charged particle reaction products from d-d fusion in a deuterated palladium think film. A silicon nitride encapsulated palladium thin film (3400 Å thick and one cm^2 area) was evaporated on top a nuclear semiconductor detector and implanted with an 80 keV D_2^+ beam in an ion implanter. A first run of this experiment showed charged-particle signal pulses after the film was loaded to more than 100% and the beam turned off. The results were not conclusive. A second run failed to produce any results. More experimental runs are expected in the near future.

COMMENTS

[The presentation by Dr. Lopez described the use of a novel encapsulation mechanism to seal ion implantation targets. Ed.]

A thin (200 A) Ti layer was needed between the 1000-A-thick coating layer and the Pd to prevent peeling. The thicknesses of the layers were optimized such that the deuteron energy would be <30 KeV when it reached the Pd, and that it would be stopped largely within the Pd [rather than the coating or detector]. In addition to deuterium loading to an estimated composition greater than $PdD_{1.5}$, bombardment with 45 KeV ^6Li ions was also performed (calculated average loading 0.013 Li/Pd). A Quadtran 500-PN Si semiconductor detector was used; count rates of 10/minute or greater were recorded during the time the sample was being cooled. Instrumental problems prevented neutron and other measurements.
[The degree to which encapsulation minimized deuterium loss is unclear, especially as it was noted during discussion of another presentation that diffusion rates decrease considerably at high loading. However, the deposition of the sample directly on the charged particle detector is also interesting. Ed.]

JAPAN - PULSED ELECTROLYSIS

Ryoichi Taniguchi and Takao Yamamoto (U of Osaka, Japan), "High Sensitivity Measurement of Charged Particle

Emission with use of the Pulsed Electrolysis Method", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

The charged particle detection is one of the most sensitive methods to catch the evidence of the possible cold nuclear fusion. Using the pulsed electrolysis method, we have attempted to increase its sensitivity further and to detect weaker cold nuclear reactions.

Charged particles were detected by a silicon surface barrier detector. The detector was set under the bottom of a cell and close to a thin palladium-foil cathode. The electrolytic current of the D_2O cell was intermitted at regular intervals about several hours. The foreground (current on) and background (current off) were measured alternately. These data for the same current wave form were summed up so that the effect of the background radiation was reduced and the signal-to-noise ratio was increased.

The experimental results, counting rate, and the energy spectrum suggested that some species of nuclear reaction occurred in the cathode. The reaction rate, 10^{-26} fusion per sec per d-pair, was about two orders of magnitude lower than that reported by Jones et al.

COMMENTS

[The experiment described by Dr. Taniguchi is unusual in that it was designed to allow charged-particle detection in an electrolytic rather than gas-loading experiment. Ed.]

The cell current was alternately switched on for 3 hours and off for 3 hours. The total current was only 30 mA. Power line noise was eliminated through the use of a battery. Background count rates were 0.42 +/-0.17/hour.

[It is possible that the low current density and periodic switching off of the current may have prevented a larger effect. Ed.]

JAPAN - CRACK MONITORING

Ryoichi Taniguchi and Takao Yamamoto (U of Osaka, Japan), "Relation between Charged Particle Emission and Induced Current Pulse Noise on the Electrolysis Electrode", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

The electric discharge when the micro-crack was propagated in the cathode material, if the fracto-fusion theory would be true, would be detected as the current impulse by the use of the electronic measuring technique, and the charged particle emission would be observed at the same time. We have tried to detect the pulse and investigate the relation to the charged particle emission.

A charged particle detector was attached close to a thin palladium-foil cathode and current pick-up (f_o < 100 MHz, sensitivity for the pulsed input was about 0.2 pico-coulomb), was set at the anode input. The high frequency component in the anode current, which would be induced by the crack-discharge on the electrode, was measured by the pick-up and counted by the PHA with charged particles at the same time. The induced current pulses on the anode current, about a few counts per hour, appeared at the beginning of electrolysis and decreased slowly. The pulsed noise seems to have some relation to the temperature of the electrolyte, but no simple relations to the charged particle data.

COMMENTS

[The described attempt to measure current pulses in the anode due to shock waves produced by the cracking of the cathode was questioned by the audience in the subsequent discussion. Ed.]

TEXAS A&M - NEGATIVE REPORT

K.L. Wolf, L. Whitesell, J. Shoemaker and H. Jabs (Texas A&M), "A Search for Charged-Particle Emission from Deuterated Titanium Alloys", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Reports of energetic charged-particle emission from deuterated titanium foils have been investigated. Foils of 6-6-2 titanium alloy have been vacuum annealed and converted to TiD in a quartz tube furnace at 700 degrees. Each Ti sample was mounted between thin stainless steel frames, which produced an exposed area of approximately 300 mm^2 each. Samples were mounted on a cold finger in a high vacuum system and cooled to liquid nitrogen temperatures, followed by a 24-hour warm-up period. Two samples were run in each cycle, each viewed by a silicon solid state detector system. A delta E-E telescope of 100 mm^2 area (16 micron and 300 micron thicknesses) was used for one sample, and a 450 mm^2 area, 300 micron thick single detector counted a second sample for each

run. Electropolished Ta defining apertures were situated 1 cm from the Ti samples for both systems, allowing large solid angles. Event-by-event data collection allowed unambiguous particle identification in a delta E-E map, with good sensitivity even to energetic protons. In six samples, each cycled four times, not a single charge-one particle was observed. Alpha particle background is a few counts per day. A large system is being instrumented to attempt to measure the branching ratio associated with the neutron emission data of Menlove, et al. {Work supported by the Electric Power Research Institute and by the U. S. Department of Energy.}

COMMENTS

[Dr. Wolf's presentation described an unsuccessful attempt to reproduce the Ti charged-particle experiment by Dr. Cecil. Ed.]

It was noted that, where possible, measurement of the production of the energetic tritons in such experiments should be 8 orders of magnitude more sensitive that measurement of the decay of the tritium afterwards [due to the long half-life of tritium].

The particle telescopes mentioned consist of a pair of superimposed Si detectors with very low threshold; identification involves plots of delta-E (the loss of energy in the upper, thin) detector versus E (the total energy loss in both detectors). The detector energy response was calibrated with a ^{6}Li(n,alpha)t source.

Targets of the same Ti used by Drs. Menlove, Worledge and Cecil were used; these were purified using a quartz furnace at 800 C and a high vacuum filament. (It was noted that the latter should leave no doubt as to purity.) Various D/Ti ratios from 0.5 to 1.7 were tried, and a deuterium gradient was also used in some samples, in case the proper range of loading was very narrow. Finally, the application of stress was tried. Thus, this experiment represented a careful attempt to get the experiment to work. As noted in the abstract, six of the twenty samples were completely negative.

E. TRITIUM MEASUREMENTS

NCFI - NO Pd CONTAMINATION

K. Cedzynska, S.C. Barrowes, H.E. Bergeson, L.C. Knight and F.G. Will (National Cold Fusion Institute), "Tritium Analysis in Palladium With An Open System Analytical Procedure", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

The formation of tritium in palladium cathodes during the electrolysis of heavy water solutions comprises one of the most significant manifestations for the occurrence of cold fusion in deuterium - loaded palladium. There have been recent reports that the tritium found by many investigators in the electrolyte of "cold fusion cells" might have originated from tritium already present as a contaminant in the palladium rather than from cold fusion. We have applied the same open system analytical procedure for tritium analysis in palladium that led another group to make these claims, and we have evaluated the limitations of the technique. In 45 palladium samples, produced by three different manufacturers in various lots and sizes, we find no evidence for tritium contamination. Within the maximum error of our experiments, that is 3 DPM/ml, the palladium samples give tritium counts identical to the background of 26 DPM/ml. The major factors leading to possible errors in applying this technique are discussed. Among these are the effects of extraneous counts, color, pH and palladium concentration of the solution, as well as the possible escape of dissolved tritium gas. In extreme cases, false tritium counts of up to several thousand DPM/ml have been observed. It is concluded that this procedure may give unreliable results unless a number of precautions are observed. Closed system analytical procedures are, therefore, preferred.

COMMENTS

[In contrast to the presentation by Dr. Wolf, in which occasional high levels of tritium contamination were reported, this presentation by Dr. Cedzynska showed no contamination in as-manufactured Pd in an equally large number of experiments (135) involving both open and closed systems. Ed.]

In the open system Pd contamination test described, 0.5 g of Pd was dissolved in aqua regia to form $PdCl_2$, and the resulting solution was analyzed for tritium. (Concentrated NaOH was added to pH 13-14, the solution was centrifuged and decanted, HCl was added to either pH 2-3 or 6-7, 1 cm^3 of pH-adjusted solution was added to the scintillation cocktail, and the tritium activity was measured and compared with a standard solution containing a similar amount of $PdCl_2$ (to give the same color). Samples were from Hoover and Strong, Johnson Matthey, and Metalor; 2 samples from Texas A&M were also run.)

Various possible sources of error in tritium analyses were noted, such as escape of tritium gas during preparation (minimized in these tests by cooling the solution and limiting contact with air), color quenching due to dissolved Pd (minimized by centrifuging the solution and adjusting the pH), and chemical reaction of the cocktail and acidic buffer with impurities in the Pd. (Cu, Ag, Pt, Rh, and Ir at the 1-10 ppm level were shown to produce artificially high count rates.) It was also mentioned that Pd oxychloride can cause scintillation cocktail to deteriorate.

In the closed system test, tritium was recovered by distillation of T_2O from the aqua regia and washing the catalyst used in the gas recombination, in order to recover all of the tritium in the system. The scintillator was calibrated using two blanks containing H_2O of a known tritium content, and the efficiency of the collection was tested by electrolysis of tritiated water. The 90 samples gave 27.2 ± 1.1 dpm/ml, similar to the 27.1 ± 1.1 for 30 measurements of background on the scintillation cocktail; 1.1 dpm/ml would be equivalent to a sensitivity of T/Pd = 1.6×10^{-17}.

In the subsequent discussion, it was noted that the analyses did include samples which generated tritium in NCFI experiments. Dr. Barrowes later suggested other groups save a portion of their as-received Pd, and if tritium later appears to be produced, the NCFI lab can analyze this sample of the metal for contamination. Dr. Barrowes also noted that if random coincidence counts in tritium analyses are greater than 5% due to chemiluminescence, the resulting nonlinearity will give problems, and that efficiencies less than 35% can also signal a problem (unless the lowered efficiency is simply due to the solution being dark).

TAIWAN - Pd ELECTROLYSIS

Chun-ching Chien, T. Chen Huang (Institute of Nuclear Energy Research, Lung Tan, R.O.C. [Taiwan]), "Tritium Production by Electrolysis of D_2O", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Twenty-six electrolytic cells have been examined for tritium production. Palladium rod was used as the cathode and LiOD in D_2O was used as the electrolyte. Significant amounts of tritium (10^2-10^3 times background) were found in three cells. In one experiment, the tritium production was of zero order with a rate constant about 2.2×10^7 T-atoms/sec, and the incubation time was about 5 hours. The reaction was sustained for more than one month. Preliminary results indicated that the tritium production can be either triggered or quenched by changing of D.C. voltage.

COMMENTS

[The Pd electrolysis experiment described by Dr. Chien showed a very suggestive correlation of high tritium production with current density. Ed.]

The cells described contained Pt anodes and 0.1 M LiOD; total current was up to 2 A. An open system was used, with tritium being measured in the electrolyte only.

After 10 days, tritium levels in one cell were reported to be 1200 times background (over 10^7 dpm/ml versus slightly over 10^4 dpm/ml). In a second cell, levels rose to 5×10^6 dpm/ml in 2 steps, which were correlated with two of the increases in the voltage. In a third cell, levels appeared to rise linearly; by extrapolating to the background level, the estimated time before tritium production began was suggested to have been less than 10 hours.

LOS ALAMOS - Pd + Si

T. Claytor (Los Alamos National Laboratory), "Tritium Generation in Pd-Si Systems; Gas and Liquid Analysis Facilities for Detection of Tritium"

COMMENTS

[The experiments described produced tritium using pressed gas-loaded Pd+Si powders or thin films and very high voltages. No abstract was available. Ed.]

It was noted that among the facilities available at Los Alamos is a large data base on D and T behavior in Pd. For instance, high-temperature desorption isotherms and separation equations for H, D, and T are available at Savannah River.

Procedural parameters which have been varied in Pd-Si-D experiments performed to date include the voltage, pulse width, repetition rate, pressing, surface asperity, and direction of current. Variations in the materials include the oxide layer, gas purity, foil or powder, gas pressure, Si size distribution, Si oxidation, and binder.

Large amounts of Pd were used, ranging from 11 to 105.5 g. The Pd currently used is from Engelhard. Analyses showed the most significant impurity to be oxygen, along with smaller amounts of N, C and Cl. Samples were loaded with D_2 gas at 200 psi; a standard loading ratio could be obtained by use of a standard volume of gas. The gas used was also analyzed for H, D, T, and ^4He. (Organic impurities are cold-trapped.) After a run, dehydriding is performed at 200 C in a vacuum to completely extract any tritium. (If the sample is not completely dehydrided, errors could result from separation effects.)

The powder was tested for tritium contamination by being pressed, hydrided, and dehydrided; less than 0.2 nCi/g were found. Each gas bottle used was analyzed for tritium content before and after use. (The content was found to vary significantly from bottle to bottle.) Also, the inside of the chamber was carefully cleaned before use with abrasive, alcohol and acetone; after evacuation, D_2 was flowed through it and the gas analyzed for tritium contamination.

Various examples were shown; for example, in contrast to the negative (1 ± 3 nCi) results in all samples with sulfur surface treatment, cells 19-21, with a greater number of alternating Pd and Si layers than preceding cells, gave 56-214 nCi excess tritium after dehydriding (but not before, indicating that this was not due to contamination in the gas used). [In contrast, estimated tritium production in cell 2 had been 170,000 nCi, and the next-largest production had been 320 nCi in cell 10.] Approximately 10 nCi was found in two hydrogen controls, presumably due to carryover from previously produced tritium to which the tubing has now been exposed.

At the time of the conference, 29 cells have been run. It was noted that the latest cells have all used foils, which can be reused (whereas the powder sinters), and which raise fewer contamination questions. These have also given small amounts of tritium production, but additional controls are still being run.

In contrast, only weak evidence for neutrons has been found, with bursts to 100 counts in 10,000 seconds, equivalent to 3-1/2 sigma above background overall and 4 sigma below 0 C. Thus, the neutron/tritium branching ratio for the powders used was typically on the order of 3×10^{-9} or less, and 3×10^{-8} or less for the foils. (Due to the large uncertainties, these values should perhaps best be considered upper limits.)

During the subsequent discussion, it was noted that the oxidation of the Si determined how high a voltage could be applied; voltages used were up to 2900 V, and it was suggested that higher voltage may have given better T production. The diameter of the powder used was 0.3 microns. It was noted that one of the biggest problems experienced with the early cells was warping.

JAPAN - PRELIMINARY RESULTS

Osuma Matsumoto, Kan Kimura, Yuko Saito, H. Oyama, Tsuyoshi Yaita (Aoyama Gakuin U, Japan), "Tritium Production Process"

COMMENTS

[In this Pd electrolysis experiment, neutron detection was also attempted, apparently using an unusual induced-fission detection method. No abstract was available. Ed.]

Experiments involved Pd or palladized Pd cathodes in D_2O + 0.5 M D_2SO_4. Neutron detection used a fission track method; a uranium acetate plate with polyethylene backing gave track densities slightly greater than H_2O and unelectrolyzed D_2O controls (up to 188/cm^2 versus 36-116/cm^2.) The corresponding rate was reported to be 2×10^{-3}/cm^2/sec, or 10^{-24} fusions/sec. In addition, tritium was measured by liquid scintillation; levels after electrolysis were 40.6 ± 1.8 dpm, versus 32.9 ± 1.6 before. Finally, using temperature-controlled desorption, the gas in the electrode was analyzed by mass spectrometry and found to give larger mass 5 and 6 peaks than when pure D_2 was introduced; however, much higher resolutions would have been necessary to indicate whether these in fact contained tritium. (A resolution of 1 part in 850 is necessary to distinguish DT and D_2H, and 1 part in 587 is necessary to distinguish T_2 and D_3.)

INDIA - EXPERIMENTS TO DATE

M. Srinivasan, A. Shyam, T.C. Kaushik, R.K. Rout, V. Chitra, L.V. Kulkarni, M.S. Krishnan, S.K. Malhotra, V.G. Nagvenkar (Bhabha Atomic Research Centre, Trombay, India), and P.K. Iyengar (Atomic Energy Commission, India), "Observation of Tritium in Gas/Plasma Loaded Titanium Samples", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

In search of the anomalous fusion phenomena termed as cold fusion, several techniques have been employed at Trombay to load D_2 gas into metallic titanium. In many of these experiments, significant amounts of tritium have been detected in the deuterated samples/targets. Tritium levels in the near-surface region of these samples have been measured by a variety of techniques including direct counting of tritium betas with a 2-pi geometry gas-filled proportional counter or indirectly through the measurement of the 4.9 keV Ti K X-rays excited by these betas and autoradiographic imaging with the help of medical X-ray films. Some of the 'very hot' samples when introduced into an ion chamber have even given rise to pico-ampere levels of current. In one of the recent experiments very high (about MBq) levels of tritium has been detected in Ti electrodes deuterated using a Mather-type plasma focus device. In another experiment about a thousand deuterated Ti lathe turnings (chips) were repeatedly cycled in liquid nitrogen (LN_2). Individual

counting of the so-treated TiD_x chips indicated the presence of about 1 to 5 kBq of tritium in more than 50% of the chips while four chips were found to contain an activity of as much as a MBq each. However, the actual 'success rate' of tritium production in the chips may be much less than 50% since we suspect that the activity in many of the chips mights have been transferred from a small number of 'successful' chips when all of them were treated together in liquid nitrogen. Investigations to confirm this possibility are in progress. The paper describes the details of the deuterium loading procedure, tritium measurement techniques and important results and conclusions of the experiments.

COMMENTS

[Dr. Srinivasan's presentation gave an overview of the wide variety of tritium experiments performed. A number of these measured particularly large amounts of tritium- for instance, on the order of $5X10^{11}$ in gas-loaded Ti and Pd. In addition, the wide variety of independent methods employed in the measurements (several of which yielded confirming spectral information as well as count rates) is notable. Ed.]

In addition to the plasma-focus and $Ti+D_2$/temperature-cycling experiments listed, other previously performed experiments included work with RF-heated targets, vacuum-annealed Pd foils and "aged" deuterated Ti targets (Ti deuteride analyzed for tritium 10-20 years after deuteration). Other experiments presently under way involve Wada-type gas-discharge experiments, deuterium ion beam implantation, tests for neutron and tritium production in chemical reactions [as reported in the presentation by Dr. Danos], and laser spot loading. In tritium measurements, in addition to the use of autoradiography (sensitive to beta and gamma emission), beta counters, and current measurements [the beta particles emitted in tritium decays are electrons], Si(Li), HPGe [high purity Ge], and NaI detectors (all sensitive to soft X-rays) as well as CaF_2 scintillators (sensitive to betas) have also been used.

In the plasma focus experiment, an approximately 12 KV discharge between a pair of electrodes in 1-10 mbar D_2 gas creates a momentary (< 1 microsecond), hot (10^6 K) plasma containing on the order of 10^{19} deuterium ions, and causes ion implantation in the surface of the target. Hot fusion in the plasma under these conditions could account for 10^{8-9} d-d fusions, but up to 400 microCi = 10^{16} tritium atoms were actually measured in one experiment consisting of 50 shots with the Ti target at positive polarity and 10 shots using negative polarity. (Another experiment using 25 positive shots gave only 8.1 microCi, and one with 30 negative shots gave 1.8 microCi.) Additional tests are planned. Measurement of the tritium by autoradiography showed that it was concentrated in wormlike features, with more diffuse areas superimposed on these presumably resulting from X-rays excited by the tritium betas. (A duplicate film on top of the first records only the soft X-rays.) The image appears unchanged for months. Neutron production was also inferred from neutron activation of Ag in the target, which gave gamma count rates of over 100/second in some cases. Rather than decreasing immediately after a shot, the gamma ray signal initially increased, suggesting continued neutron production for perhaps 15 seconds after shots, before decreasing with the proper 23 second half-life for the Ag isotope produced. The latter decrease confirms that the gamma ray signal is due to neutrons produced by the shot.

(In an experiment with an RF-heated coin, an overnight exposure of the medical X ray film also showed spotty fogging, especially around the edges of the coin.)

In the Ti gas-loading experiment, the chips were mixed together from different batches from the same source. The chips were cleaned with HCl, then degassed for several hours at 850 C. D_2 gas (1 atm) was introduced at 600 C, and the gas absorption was measured. The samples were then cooled overnight, cooled in liquid nitrogen, and allowed to warm up. [A few cycles in H_2 also may have been helpful.] Since it was suspected from previous observations of bursts that not all of the chips are active, the chips were measured individually. X rays excited by the tritium betas were measured with an NaI detector; a "hot" chip gave hundreds of counts/second with an energy spectrum corresponding to that seen with a Ti foil covering a tritium standard [i.e. the results were presumably consistent with Ti K X-rays]. The same chips gave thousands of counts/second with a beta counter, and a 10-16 hour autoradiograph showed fogging (which was spotty even though the chip was only a few mm wide). The calculated tritium levels in the hot chips (almost 1 milliCi each, or 10^{15} tritium atoms) would represent a T/D ratio of 10^{-3} to 10^{-4}; note that the quantity is 10^5 times the total tritium in the source gas in the entire chamber. None of the chips not cycled to liquid nitrogen temperatures showed high tritium levels. H_2-loaded Ti controls were also negative.

A correction was noted to the BARC autoradiography data reported at the First Annual Conference; the report that tritium production occurred only after a time delay was incorrect.

LOS ALAMOS - HYDRIDING AND TRACERS

Edmund Storms and Carol Talcott-Storms (Los Alamos National Laboratory), "The Effect of Hydriding on the Physical Structure of Palladium and on the Release of Contained Tritium".

ABSTRACT

When Pd takes up hydrogen or deuterium beyond the composition at which the sample is first converted to the beta phase, irreversible changes in dimension occur that result in an increase in volume. Repeated removal and addition of hydrogen caused the excess volume to steadily increase while the thickness increases and the other dimensions decrease. These changes suggest the creation of microcracks and/or dislocations within the metal. Such changes in the environment within Pd metal can alter the local D/Pd ratio, change the lattice spacing, affect the diffusion of impurities and, perhaps, produce fractofusion. These factors need to be taken into account in the interpretation of the Cold Fusion Effect.

In view of concern about possible contamination of Pd electrodes with tritium, a study was made using electrodes that were purposely contaminated. Tritium that has been dissolved in palladium is quickly flushed mainly into the gas during electrolysis. Much less appears in the electrolyte. Apparently, tritium that is on or near the surface can exchange with the electrolyte while internal tritium exchanges with D_2 to form DT which leaves the metal as gas through a network of microcracks. The pattern of tritium release from contaminated palladium is significantly different from active cold fusion cells.

COMMENTS

[Dr. Storms' presentation discusses irreversible changes during Pd hydriding which may be of considerable significance, as well as detailed tritium tracer experiments which can be used in studying both D and T behavior. Ed.]

While positive tritium results have shown that there can be production, negative results indicate many things can prevent it. It was noted that several factors can influence the degree of deuteration attained, which it is presumed must exceed a certain critical value for fusion to occur. First, in mixtures of hydrogen and deuterium, the H/D ratio in the alloy will not generally reflect the H/D ratio in the electrolyte; even a small amount of H_2O in the electrolyte (which can result from absorption from the air) dilutes the amount of deuterium in the electrode significantly because Pd takes up hydrogen preferentially. (For example, the fraction of deuterium in the electrode can be 60% while the fraction in the electrolyte is 90%. Second, higher charging current densities may increase loading by making more deuterium available to replace that which is lost. [However, note that the presentation by Dr. Wolf indicated that higher current may also trigger increased losses.] Third, surface poisons, by creating overpotentials, can also play a very important role by affecting the rate of interconversion of atomic and molecular species on the metal surface. Finally, the concentration of micropores may play a very important role in determining the attainable loading.

To study the latter effect, the change in volume of (arc-melted and rolled) Pd disks were measured as they took up hydrogen. (A similar effect would be expected for deuterium.) The volume increases reasonably linearly from H/Pd = 0.1 to 0.6, at which point all of the alpha hydride phase has been converted to the beta phase; the total volume increase is 10% at H/Pd=0.6. Above this point, the increase is still linear but faster- in excess of that expected from the increase in the lattice parameter. If the loading is then reduced again, the volume decreases only at the rate characteristic of the change in the lattice parameter (i.e. parallel to the curve for low loading); thus even when all of the hydrogen has been removed, the volume is a few percent greater than original. Repeated cycles can build up at least 30% excess volume. In another experiment using a charging current of 20 rather than 200 mA, excess volume appeared while the alpha phase was still being converted to beta phase, demonstrating that the effect is also related to the rate of loading.

As the excess volume forms, the disk diameter decreases and the thickness increases- it tries to become a sphere. With (extruded) rods, the effect is different- some samples showed changes consistent with only lattice parameter changes, and others developed excess volume. One of the latter appeared to represent a borderline state; it did not develop excess volume until placed in a different cell. Note that since the development of excess volume causes rod lengths to decrease, the length cannot be used to infer the amount of loading, as has been done in some previous studies.

A photomicrograph of a specimen which had developed excess volume showed a trail of elliptical or tubular cavities (1-5 microns in diameter, 2-10 microns long). These were not enough to account for the excess volume, but could allow deuterium to move out if these pores intersected the surface.

Decreases in loading were measured following development of excess volume. For example, the loading of one sample was shown to drop from approximately 0.77 to 0.66, the amount in equilibrium with D_2 gas at 1 atm. Furthermore, the loading stayed low: once the excess volume formed, it was not possible to get back to the high stoichiometries.

An additional experiment used tritium as a tracer to study the loss of deuterium from the electrode and the behavior of tritium contamination. (The Pd was charged in an electrolyte containing tritium; the electrolyte was then replaced with relatively tritium-free D_2O + LiOD, and charging was continued.) It was found that the recombinant started out high in tritium and dropped in tritium content over tens of hours, while the electrolyte during this time slowly increased in tritium content. When levels stabilized after 120 hours, 96% of the tritium was in the recombinant versus 4% in the electrolyte. There was no delay before the tritium began to appear [such as was noted in the presentation by Dr. Wolf]. Thus if tritium contamination is present in the electrode in an available form (or if tritium is produced below the surface), it should be lost to the gas phase quickly; if it appears in the gas after a long time, or appears predominantly in the electrolyte, this would not be consistent with contamination, but with production at the surface of the electrode.

In addition, these results indicate that a good way to recover all of the tritium in the electrode after the experiment in order to measure it would be to run the Pd as the anode; under these conditions the tritium should go almost quantitatively into the electrolyte, rather than into the gas when it is run as the cathode above.

The rate of deuterium loss, as indicated by the tritium tracer levels, was found to increase with current up to a certain point, then level off (above 200 mA in this experiment). It was suggested that the deuterium flux moving steadily through the electrode, forming gas on the inside of a micropore, and escaping where this intersects the surface may have reached a maximum value at sufficiently high current densities. At higher currents, greater loading may thus be possible.

In the discussion following the presentation, it was noted that XRD patterns of the loaded Pd initially show line broadening due to the high stresses created by the hydriding, but that after micropore formation occurs the lines become narrow again, showing that the stresses a have been relieved. It was also noted that Li in the alloy results in the generation of larger amounts of excess volume, and that gas loading can prevent excess volume if sufficiently high pressures (such as 5 kilobars) are used. In one experiment, it was observed that if micropore formation was not seen on the first cycle of hydriding, it would generally not occur on subsequent cycles either. Finally, it was noted that the observations by Henry Randolph at Savannah River showed that gas came off at specific sites in hydrided Pd, and it was suggested that these could reflect sites of micropores rather than of recombination of atomic H to H_2.

TEXAS A&M - TRITIUM IN CONTROLS

K.L. Wolf, D. Lawson, J. Shoemaker, B. Dean and D. Coe (Texas A&M), "On the Observation of Tritium from the Electrolysis of Heavy Water".

ABSTRACT

A test of the reproducibility of tritium production in D_2O electrolysis with Pd-Ni-LiOD cells has proved to be negative. The results of Packham, et al [J. Electroanal. Chem. 451, 1989] are considered to be spurious, and are attributed to tritium contamination. An extensive study with over 100 electrolytic cells has shown that the frequency of occurrence of tritium sightings is explained by the tritium contamination found in the palladium metal stock. A cold fusion mechanism is not supported and implications are discussed for many reported tritium sightings in other studies which were conducted without sufficient blank and control experiments. {Work supported by the U.S. Department of Energy and by the Electric Power Research Institute.}

COMMENTS

[Dr. Wolf's presentation of results from additional control experiments suggests that the previously reported production of tritium from electrochemical cells such as those previously prepared by the Bockris lab (Pd-Ni cells in D_2O + 0.1 M LiOD, with recombination of gases) may have been due to contamination. Note that the opposite conclusion is suggested by other presentations by Dr. Storms of Los Alamos (indicating that tritium contained in Pd does not behave in the same fashion as tritium produced during electrolysis) and Dr. Cedzynska of NCFI (in which analysis of an equally large number of samples found no contamination). Ed.]

The previous data involved 75-80 cells prepared by Appleby and Martin, which showed no tritium, and 30-40 prepared by Wolf, half of which showed tritium.

Tritium levels in additional control cells prepared in the same fashion as previously were reported to increase from <500 to as much as 14,500 cpm/ml after some days, implying that tritium contamination in a cell need not show up immediately. In all, two of 27 H_2O controls were reported to give 10^{12-13} atoms of tritium, comparable to (within an order of magnitude of) the levels in the D_2O cells reported previously.

In addition, the loading was also monitored to see whether this could account for the need for prolonged electrolysis. The maximum D/Pd ratio attained for a 1-mm-diameter rod was inferred to be approximately 0.7 based on the volume increase; gravimetric measurements gave a value approximately 10% higher. The majority of the loading occurred quickly, with the D/Pd ratio reaching 0.5 in the first few hours. After 10 days, loading began to decline, reaching 0.5-0.55 after 50 days; increasing the current density also gave a measurable decrease from 0.6 to 0.5.

Dr. Wolf noted that more work was done by their lab on the controls than on the samples. All samples were counted twice, 24 hours apart; positive results were then rechecked on the lab's homemade tritium counter. Two phototubes were used in coincidence mode, and the results were compared with the standard tritium beta spectrum. This proved a good match (much better than the match for any other isotope), confirming that it was in fact tritium which was being measured. (However, it was noted that measurement of the energy spectrum made using a commercial tritium counter could be ambiguous if the counter had a logarithmic response; in this case the tail of the energy distribution will not show up well and the identification would not be as clear-cut.)

Several possible ways to get mistaken tritium results were listed: spurious counts due to chemical interference, tritium contamination during cell construction or refill, and (if levels are low) failure to allow for increase in the tritium concentration of the electrolyte during electrolysis (due to the separation factor). To check for contamination, an H_2O blank and regular assay of any fill electrolyte would be necessary; it was also noted that spot as well as bulk contamination of the electrode may be possible. On the other hand, it was also noted that in open systems, tritium which is actually produced can be missed if it is in the gas but not in the electrolyte. Previous tritium studies were discussed, and Dr. Wolf noted that very few such studies eliminated all possible questions.

During the discussion afterwards, it was noted that for equal current, 30% more power was used in electrolyzing D_2O than H_2O. Problems with hydrogen embrittlement of the electrode were also mentioned, leading to splitting of the electrode in one group's experiment. Finally, Dr. Wolf noted that the experiments discussed here included attempts to increase tritium yield by bombardment and by seeding with smaller amounts of tritium.

F. THEORY PAPERS

BYU - DEUTERIUM DYNAMICS STUDY

M. Berrondo (Brigham Young U), "Molecular Dynamics of Deuterium in Palladium Lattice"

COMMENTS

[The study in progress uses computer simulations of Pd deuteride using molecular dynamics to study parameters which may enhance conventional fusion under nonequilibrium and transient conditions. No abstract was available. Ed.]

The strong experimental evidence for the role of nonequilibrium and transient conditions was noted. Factors incorporated in the dynamical modeling of the deuterons included varying crystal geometries and stresses, the presence of defects and vacancies, and the development of cracks and phase transitions. Quantum mechanical effects were incorporated only when necessary.

(The starting point was calculations of potential energy; in modeling elastic properties and interactions of D with D and Pd, it was noted that individual potentials were not additive in this case. Electronic motion was incorporated using electron densities calculated from quantum mechanics, rather than representing atoms as point charges and using 2-body nuclear repulsions. Numerical solution of Newton's equations was then performed to calculate deuteron trajectories within a cell. At equilibrium, energies of preferred deuterium sites, potential barriers for deuterium diffusion, effects of imperfections and nonequilibrium conditions on diffusion, average residence time in a site, and distances of closest approach were calculated. From this information, reaction rates due to conventional fusion were estimated.)

Preliminary calculations under static conditions, using calculated deuteron potential energies of 1.6 eV in the preferred octahedral site, 1.9 eV in tetrahedral sites, and 2.0 eV for the barrier between Pd atoms, gave a reasonable estimate of $1.9X10^{-3}$ cm^2/sec for the diffusion coefficient at 1000 K.

CAL POLY - TRM MODEL UPDATE

Dr. Robert T. Bush (Cal. Polytechnic), "Production of Tritium, Neutrons, and Heat Based Upon the Transmission Resonance Model (TRM) for Cold Fusion", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

The TRM has recently been successful in fitting calorimetric data having interesting nonlinear structure. The model appears to provide a natural description for electrolytic cold fusion in terms of "fractals". Extended to the time dimension, the model suggests a connection between cold fusion and Chaos Theory with regard to the phenomenon of heat "bursts". The TRM combines a transmission condition involving quantized energies and an energy shift of a Maxwell-Boltzmann energy distribution of deuterons at the cathodic surface that appears related to the concentration overpotential (hydrogen overvoltage). The model suggests three possible regimes vis-a-vis tritium production in terms of this energy shift, and indicates why

measurable tritium production in the electrolytic case tends to be somewhat unusual in the absence of a "recipe". Below a shift of approximately 2.8 meV there is production of both tritium and measurable excess heat, with the possibility of accounting for the Bockris curve indicating about a 1% correlation between excess heat and tritium. However, over the large range from about 2.8 meV to 340 meV energy shift there is a regime of observable excess heat production but little, and probably not measurable, tritium production. The third regime is more hypothetical: It begins at an energy shift of about 1 keV and extends to the boundaries of "hot" fusion at about 20 keV. It suggests a possible connection to the dendrite hypothesis of Bockris and others. A new type of nuclear reaction, trint (for transmission resonance-induced neutron transfer), is suggested by the model leading to triton and neutron production. A charge distribution "polarization conjecture" is the basis for a theoretical derivation for the low-energy limit for an energy-dependent branching ratio for D-on-D. When the values of the parameters are inserted, this expression yields an estimate for the ratio of neutron-to-triton production of about 2.64×10^{-9}. The possibility of some three-body reactions is also suggested. A comparison of the TRM's transmission energy levels for palladium deuteride and titanium deuteride is interesting when compared to recent data on neutron emission by Zelenskii of the Harkova Institute (USSR).

COMMENTS

[This updated version of the coherent-interaction model presented by Dr. Bush at the First Annual Conference is scheduled to appear in Fusion Technology in March 1991, with an experimental paper to appear in the following issue. Ed.]

The model involves greatly enhanced tunneling due to quantum mechanical effects in a regular lattice. The model has now been extended to incorporate the Butler-Volmer electrochemical equation and model an energy shift due to the activation and concentration overpotentials (i.e. resulting from the electrolysis). It was noted that a surface effect was predicted, and that the model can now explain why prolonged electrolysis may be necessary: by changing the cathode surface (for example, by platinizing it, if trace quantities of Pt are present), the hydrogen overvoltage is changed.

(It was noted that development of the model was initially prompted by a conjecture by Leaf Turner at the Santa Fe conference regarding De Broglie wave transmission properties of a lattice with sufficient regularity. A much earlier analysis of a barrier-well-barrier-well... [comb filter] system (D. Bohm, Quantum Theory, 1951) was also noted, in which it was pointed out that interference phenomena in periodic structures can give high transmission across the barriers, and that an optical analogue involving light passing through a series of glass/air interfaces may be demonstrable.)

Experimental evidence for the theory was discussed. For example, it was noted that in data by Dr. Eagleton presented at the First Annual Conference, although a straight line generally fit an excess power versus current density graph well, one point out of the 12 was only half as high as expected. Dr. Bush indicated that at the time he speculated that the odd point might not be an error, and followup experiments shown indeed indicated a reproducibility in the dip. Possible peaks and dips in output at particular temperatures were also noted in an experiment by Zelenskii in which Ti and Pd films were cooled and allowed to warm up. Although the statistics were poor, a suggestion of neutron emission in Ti matching proposed lines at -30 C and also perhaps 600 C in Pd was noted, as was a possible match for the proposed 200 K line (although most higher lines were not clear).

Dr. Bush encouraged other researchers besides Dr. Eagleton to attempt to reproduce the behavior predicted, such as dips in output at certain values of current density or temperature (when all other variables are held the same) and cessation of the effect above certain current densities (which could vary depending on the surface condition of the electrode). (It was mentioned that several researchers had already indicated that they planned to perform such tests.) An experiment performed by Dr. Jones of BYU was also cited, in which deuterated Ti was warmed from liquid He in an attempt to see neutron emission corresponding to the proposed Ti n=0 line; it was suggested this test might be worth repeating.

During subsequent discussion, Dr. Bush indicated that his model might be consistent with the band model of Dr. Chubb. In a discussion of the Eagleton data, it was noted that the increase in current density would also have a secondary effect through increasing the cell temperature. [In a discussion of Dr. Bush's previous paper, a potentially confusing aspect was pointed out: the calculated Tn values which are shown represent energies expressed in the same units as temperature, rather than actual temperatures.]

ITALY - HOT CLOUD IN CLUSTER IMPACT

G.F. Cerofolini (Functional Materials Laboratory, San Donato, Italy) and A. Foglio Para (Istituto di Ingegneria Nucleare, Milano, Italy), "$(D^+ + D^+)2e^-$ Binuclear Atoms as Activated Precursors in Cold and Warm Fusion", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

The formation of a hot cloud in which an activation energy is required in order to promote a (D,D) fusion process, has recently been hypothesized as the mechanism of the positive results obtained by Beuhler et al. (Phys. Rev. Lett. 63, p 1292, 1989) following the impact of large clusters of heavy water on deuterium-containing targets. The hot cloud is an intermediate stage in the dense collisional cascades resulting from the implantation of large clusters (or of heavy molecules) onto condensed matter targets.

The activation energy is required to lead to the formation of a "binuclear atom", i.e. a metastable exotic atom in which, generally speaking, two nuclei with atomic numbers Z_1 and Z_2 are separated by a distance $r << a_o/(Z_1+Z_2)$ (a_o being the Bohr radius) and are surrounded by Z_1+Z_2 electrons arranged approximately in the same configuration as in the atom with atomic number Z_1+Z_2. The binuclear atom $(D^++D^+)2e^-$ should have an internuclear distance r approximately 0.5 X a_o and a stability against dissociation of a few electron-Volts at least, as a result of a qualitative estimate. Detailed simulations of molecular dynamics are required, however, to evaluate the useful energy for the activation process and for the de-excitation.

In the paper the model is applied not only to experimental results involving implantation of large clusters on various materials, but also to chemofusion and tentatively to electrolytic fusion.

COMMENTS

[The presentation by Dr. Cerefolini proposes a new tunneling mechanism in order to explain the relationship of the fusion rate on the kinetic energy in the cluster impact data published by Beuhler et al. Regardless of the correctness of the model, the suggestion that this data could indicate a very low-energy reaction mechanism is intriguing. Ed.]

In the Beuhler experiment, relatively high fusion rates were observed during low-energy impacts by D_2O clusters on deuterated targets. It was observed that for large clusters, the slope in plots of yield versus cluster size characteristically became approximately linear. Data at constant cluster size and data at constant energy both fit an Arrhenius plot with the same slope. [Such plots are commonly used to determine activation energies of chemical reactions.] The activation energy which would be suggested for this fusion reaction was approximately 35 eV. Based on the Coulomb repulsion, such an activation energy would indicate that the necessary separation between deuterons, as indicated in the abstract, would be half the Bohr radius.

It was suggested that at this point a shift to a different electronic configuration with lower energy may occur, inhibiting the deuterons from moving apart again. [W. Kolos and L. Wolniewicz, JCP 41, p 3633, 1964, and JCP 49, p 404, 1968 were cited supporting such a tunneling mechanism.]

Other previous explanations, including Koonin (involving inflight fragmentation and a greater than expected spread in the cluster masses) and Cecil and McNeil (Phys Rev Lett 64, p 2210, 1990, involving ionization of backstreaming deuterons) were also mentioned.

During the subsequent discussion, it was indicated that scattering experiments were to be performed to determine whether the proposed metastable state actually exists.

CHUBB - LINC MODEL UPDATE

S.R. Chubb and T.A. Chubb (Research Systems, Inc.), "Lattice Induced Nuclear Chemistry", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Just as electrons cease to be point particles when they are injected into a solid, deuterons cease to be point particles when they become bound to the interior of a deuteride host. Additional quantum mechanical effects, well-known from the behavior of electrons bound within a solid state environment at low temperature, have the potential to profoundly affect the transport of deuteronic charge in a solid in a manner that runs contrary to conventional wisdom based on free space thinking. During the prolonged electrolysis of LiOD by Pd, these kinds of effects can be used to explain the associated anomalous cold fusion heating phenomenon through interplay between the highly non-equilibrium circumstances associated with overcharging PdD_x beyond the value x=1 and the quantum mechanical implications that result from 1) periodic order, 2) lattice-induced broadening of deuteronic charge, and 3) the large lattice strain energies that result when individual deuterons compete for a common location. This interplay provides a means for satisfying the necessary conditions for the formation and subsequent nuclear decay of a new, chemical matter phase, which we have named Bose Bloch Condensate (BBC). The periodic PdD lattice induces formation of the BBC as a means of eliminating localized lattice strain energy costs by allowing a small number of injected deuterons to occupy energy bands provided by the periodic potential of PdD. Lattice strain energy costs are further reduced when the coulombic repulsion between deuterons remains uncorrelated on the scale of

electrostatic interaction for a sufficiently long time. As a result, it becomes possible for deuterons within the BBC to interact collectively in a nuclear fashion with each other in a manner consistent with the prerequisite conditions which lead to the formation of the BBC. The combination of overcharging and periodic order provide the ingredients for this new form of nuclear interaction, governed by new selection rules that result from known quantum mechanical effects. We have named this new form of interaction, Lattice Induced Nuclear Chemistry (LINC). Under suitable conditions, LINC can be used to explain a wide range of seemingly different nuclear phenomena within condensed matter environments, including 1) the possibility of enhanced secondary tritium production near cracks and interfaces, 2) anomalous heat generation through ^4He production that is conventionally inhibited in free space, and 3) the possibility for isotopic rearrangements within the host. If cold fusion is the result of LINC, the phenomenon, per se, bears little resemblance to fusion since the primary forms of nuclear interaction within LINC do not result from the nuclear interaction between isolated nuclei but are initiated from the decay of the collective BBC state via collective self-interaction. In this paper, we provide an explanation of the manner in which interplay between periodic order and overcharging provide the necessary prerequisite conditions for occupation of the BBC state and the rules for subsequent interaction through LINC.

COMMENTS

[This quantum mechanical theory involves collective interactions proposed to occur within a regular lattice at even low energies to produce ^4He (produced in the bulk at low kinetic energy and expelled on crystallite surfaces, near cracks, at interfaces, and in the out-gases), with tritons and neutrons only due to secondary reactions. Ed.]

The required loading in Pd to explain cold fusion is suggested to be on the order of 1 part in 10^7 greater than $PdD_{1.0}$, with the excess deuterium, present in an ionic form, forming a nuclearly active collective Bloch state. As mentioned, the very small fractional occupation of a large number of lattice sites by such band-state D^+ would be favored since charge can be shared throughout the lattice and strain minimized. The Bloch states are wavelike; the individual particle identities are lost, and zero-point motions large enough to allow overlap and lead to fusion of deuterons are possible even at very low energies, since Coulombic correlation between the deuterons is not important on the timescale of the nuclear interaction at small BBC concentrations (on the order of 10^{-7} per Pd). (Allowable perturbations which initiate nuclear reactions must also maintain the simplicity of the system).

Reversible "nuclear interactions" (virtual coalescence fluctuations) occur at all lattice sites, in which Bloch states of chemical density are transformed into Bloch states of nuclear density ($2\ D_{BBC} <\!\!-\!\!> {}^4He_{BBC}$), with the lattice itself reversibly and coherently absorbing the momentum change (inverse Mossbauer effect; a perfect lattice would not move at all). Fluctuations leading to decay of the multiparticle state generate the observed nuclear products. (Energy may be transferred to the environment by inelastic scattering of particles in the $^4He_{BBC}$ state with electrons, coupling to phonons, etc.) Lattice disintegration terminates the band state and ends the reaction. Thus, it is desirable that the energy released is transferred collectively, as much as possible, to the lattice as a whole. Optimum lattice stability occurs when the ^4He produced is distributed predominantly to the surface.

The reactions obey a boson in, boson out selection rule, where each boson is formed from proton-neutron pairs (so that pairs are not broken): for example, $4\ D_{BBC} \rightarrow 2$ (23.8 MeV) alpha particles or $2\ D_{BBC} + D_{lat} \rightarrow {}^4He + D_{lat}$, with the energy taken up by phonons (lattice vibrations). An experiment was noted in which >20 MeV doubly-charged particles may have been seen.)

In addition to predicting the need for sufficient periodicity (and thus good-quality crystals and uniform charging) and for loading ratios greater than 1 in individual crystallites (thus possibly requiring prolonged electrolysis), this theory suggests how ^4He can be produced in the bulk electrode and expelled from the surface at low energy, why bursts may occur, and why few other fusion products are seen. In addition, such reactions could possibly account for fusion during the initial portion of cluster impacts (before thermalization takes place).

In Ti, it was indicated that the periodic order was more complicated than in Pd, and the need for modification of the boson in/boson out rule was discussed, such as:

$4\ D + e \rightarrow D + H + 2\ T^+$ (possibly 3.8 MeV and 5.4 MeV tritons). In addition, the suggestion was made that fusion may occur in the presence of 1 part in 10^7 Ag. Finally, the possibility was raised that the rare inverse isotope effect in superconducting PdD noted in the Celani presentation (2 K higher critical temperature for superconductivity in PdD than PdH) could be associated with the presence of a BBC state.

In the subsequent discussion, it was indicated that a porous surface would be favorable for expelling the He and observing the excess heat. Possible enhancement caused by seeding of He or tritium in the surface was speculated on. Dr. Chubb indicated that decay of the BBC state in the model was consistent with the model of Dr. Bush.

[Earlier presentations of this model have appeared in the July 1990 Fusion Technology and the First Annual Conference on Cold Fusion in Salt Lake City.]

NIST & USSR - NEUTRON TRANSFER

M. Danos (National Institute of Standards and Technology) and V. Belyaev (USSR Academy of Sciences), "Theoretical Studies/ Theory of Neutron Transfer Fusion"

COMMENTS

[It was proposed that high-order processes that circumvent the Gamow penetration factor through catalytic neutron transfer are sufficient to account for cold fusion rates, and that no exotic mechanisms are necessary. No abstract was available. Ed.]

The approach in the calculations has been to estimate the maximum possible rate rather than attempt to model the rate to which the process would actually be limited by other possible factors. The higher-order terms, ordinarily insignificant, are proposed to dominate at very low energies because they drop off much less rapidly than the regular Gamow term (by factors of, say, 10^{3-5}, compared with 10^{50} for the Gamow term).

The 3-body interaction suggested was shown using a Feynmann-type diagram; fusion involved a third, catalyzing, nucleus, via a fourth-order effect. It was indicated that the fusing nuclei could be D, ^{7}Li, or whatever other nuclei are available. Likewise, various catalyzing nuclei such as Ti, Pd, or ^{16}O could be possible. For simplicity, the catalyzing nucleus and one of the two fusing nuclei are assumed to be bound in the lattice and thus stationary, while the other nucleus is moving. The model uses very standard wave functions. Although the question of the branching ratio is not addressed, it was noted that it could be large. Initial momenta greater than approximately 0.1 eV are not required for the particles; in a sample calculation shown, catalysis of the ^{7}Li+d reaction by ^{16}O is modeled at thermal velocities of 10^5 cm/sec, with a maximum possible rate on the order of 10^{-5}/sec/deuteron. It was suggested that this rate was deliberately overestimated by a factor of perhaps 10^5, yet even so, the possible rate was still 10^{7-8} times the rate needed to explain the excess heat, without needing to resort to any exotic mechanism. It was also pointed out that in this example the reaction modeled was neutron-free.

[In the question session afterwards, it was suggested that the theorists need to engage in round-robin reviews of each others' work, owing to the difficulties and time lag currently involved with publication. Ed.]

POLAND - D_2 INTERMEDIATE

M. Gryzinski (Institute for Nuclear Studies, Otwock-Swierk, Poland), "Molecular Nature of Cold Fusion in Condensed Matter", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

This idea that electrons present in the matter are responsible for Coulomb barrier tunnelling is applied to explain cold fusion in solids. Arguments are given that hydrogen in a Pd lattice exists in the form of linear H_2^+ (D_2^+) quasi-molecules which during the phase transitions may collapse to the nuclear size - collapse is initiated by a change of the binding energy of the electron moving between the nuclei by approximately 2.5 eV. Relations derived entirely within classical dynamics enabled to give a quantitative description of some physical properties of Pd/H system and to make some estimations for cold fusion rates.

COMMENTS

[This presentation suggests occupation of lattice sites in Pd by D_2 rather than the normally accepted D atoms. Experimental evidence such as Mossbauer spectra could presumably be used to calculate an upper limit on the fraction of deuteriums which could be present in the form proposed. Ed.]

MIT - COHERENT REACTION UPDATE

Peter L. Hagelstein (Research Laboratory of Electronics, Massachusetts Institute of Technology), "Coherent Fusion Reaction Mechanisms", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

We have been considering a new class of nuclear reactions which have the potential for being accelerated by having numerous reactions occur "in phase" at the same time. Reactions initiated by electron capture and superradiant neutrino emission give rise to intermediate virtual neutrons for which coulomb repulsion does not play a role, and which have the potential for long range interactions due to the presence of coherence. These reactions give rise to heat as a primary product through coherent depp reactions, tritium as a secondary product from coherent depd reactions, and fast neutrons and other particles through third order incoherent branches.

COMMENTS

[This model proposes collective (many-particle, coherent) emission of essentially stationary products, involving virtual neutrons and possibly hydrogen or other atoms as well as deuterium. An earlier version of the theory was presented at the First Annual Conference on Cold Fusion. Ed.]

Recent progress in this model has included improved ideas on low-energy virtual neutron states, significant progress in quantifying the theory, and proposed new semicoherent reaction channels.

In discussing the problem of coupling of nuclear reactions to other systems, the example was used of the coupling of electrical current (which can be treated with quantum mechanics as a simple harmonic oscillator) to other systems if a sufficient nonlinearity is present, such as can be provided by electrolysis. In this case, it is conjectured that a plot of current versus voltage would be stepwise on a microscopic scale (since low grade electrical quanta are being converted into high grade chemical quanta). Another analogy involved a passive AM radio, which can rectify high frequencies to give a DC signal. In the discussion of coherence, Dicke superradiance was described, in which n emitters in phase can emit n^2 times as much; the time dependence is such that the effect takes a long time to build up, and is very spiky when it does come up.

In the model, Feynmann-like diagrams were used to show an interaction involving virtual off-shell neutrons; it was proposed that a strong scattering mechanism could provide the unusually long-range propagation necessary for cold fusion. The primary reactions involving 1s neutrons are d+e+p+p (Q=2.05 MeV), d+e+p+d (Q=5.89 MeV), and d+e+p+^{3}He (Q=20.21 MeV).

An example was given in which the calculated total fusion rate peaks for a D/H ratio of 2:1, while heat was optimized at 15% H and 85% D. A maximum triton kinetic energy for the depd reaction in Ti was likewise calculated as 5.5 MeV, with Ti kinetic energies up to 0.4 MeV. For the depp reaction, maximum deuteron energies were 1.97 MeV, and for the dep^{3}He reaction, maximum ^{4}He energies were between 18 and 19 MeV. It was noted that high-Z nuclei are favored for taking up the momentum.

This model also makes the very interesting prediction that spatial separation of the inductive coupling [i.e. reactants] and the nonlinearity [of the electrolysis process] should be possible.

MISSOURI - SURFACE TENSION; ALLOYS

Peter H. Handel (U of Missouri), "Influence of Surface Tension, Nucleation Centers, and Electron Effective Mass on the Achievable Level of Electrolytic Deuterium Loading", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Electrolytic loading of completely immersed metallic cathodes is limited by the process of nucleation of small deuterium bubbles at the surface of the cathode. The nucleation usually occurs at certain points known as nucleation centers. In the absence of any nucleation centers, which rarely happens, homogeneous nucleation will finally start at random on the cathode surface at a considerably higher level of hydrogen loading. We calculate the additional increase in the chemical potential of deuterium in homogeneous nucleation conditions to be about 1.2 eV. This could be connected with the irreproducibility and sporadic nature of cold fusion reports, although we have no proof for this conjecture.

From electronic specific heat measurements, the average thermal effective mass m_{th} of electrons in hydrogen-absorbing metals is found to be about three free electron masses m_o, while the average of m_{th} in hydrogen-rejecting metals turns out to be just m_o. This experimental fact indicates a certain influence of the thermal effective mass on hydrogen affinity. We conclude with a discussion of heavy fermion metallic compounds, and suggest their use as cathodes in future electrolytic or high-pressure deuterium gas loading "cold fusion" attempts.

COMMENTS

[This presentation involved two separate points- the possible role of high surface tension in electrolysis experiments, and possible correlation of effective electron masses in particular alloys with favorable hydrogen affinity. Ed.]

The absence of nucleation centers for the formation of D_2 bubbles during electrolysis is suggested to be advantageous by allowing higher loading before bubble formation eventually occurs due to random fluctuations. (Except at extremely low current densities, bubble formation is typically the dominant process by which deuterium is lost from the electrode.)

In the absence of nucleation centers, formation of D_2 bubbles will be postponed the longest when the surface tension of the electrolyte is high. For example, it was estimated that the maximum achievable level of electrolytic loading in D_2O was equivalent to a D_2

pressure on the order of 10^{20} atmospheres, provided the surface tension is not lowered by traces of detergents and similar impurities. (It was later noted that very small amounts of grease also react to create detergent in basic solutions.)

A possible test of the effect of surface tension was suggested in which a drop of detergent is deliberately added to a cell before or after it becomes active.

With regard to the effective mass, it was noted that the high effective mass states at the surface of the Fermi sea are Bloch states, and thus cannot be used directly to provide localized electrical charge distributions capable of catalyzing d-d fusion in the same fashion as a muon. Nevertheless, as noted, metals with a high density of such states typically absorb large amounts of hydrogen. Accordingly, it is suggested that alloys such as UPt_3 and $CeRu_2Si_2$ be tested. [Note- despite favorable equilibrium loading values, formation of hydrogen-blocking surface oxides by such non-noble materials may be a problem in conventional electrolysis experiments (i.e. ones other than molten-salt cells). Ed.]

SWEDEN - ION PRESSURE EFFECTS

Magnus Jandel (Royal Institute of Technology, Stockholm, Sweden), "Pressure Enhanced Fusion Rates in Lattice Channels", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

The fusion rate of a pair of deuterons in a narrow lattice channel can be significantly enhanced both by electron screening and by the pressure of neighboring spectator ions. The ion pressure effect can not be accurately described by the mean pair potential but requires a careful consideration of statistical fluctuations of the ion configuration. Based on a solvable model for a strongly coupled Coulomb plasma we develop a theoretical scheme for calculating fusion enhancement factors in a one-dimensional plasma with screened Coulomb interactions where ion pressure effects are accurately described. The result is compared to some recent Cold Fusion experiments.

COMMENTS

[This model, which focuses on the effect of fluctuations in deuteron positions, calculates an enhanced conventional fusion rate due to such effects in a lattice, using a simplified 1-dimensional model. Ed.]

A variety of simplifications are used such as:
1. 1-dimensional, 1-component plasma;
2. Simple $1/r\ e^{-r/d}$ ion-ion potentials; and
3. Only nearest neighbor interactions), plus optimistic screening assumptions. Using quantum mechanical time correlation functions, the effects of the surrounding ions and the fluctuations were shown to increase the Coulomb barrier penetration rate by 3-5 orders of magnitude in Pd at high loading over that calculated using only the classical mean potential. Three-dimensional calculations have not yet been carried out, and possible transient phenomena are not yet taken into account.

In the subsequent discussion, it was pointed out that thermal equilibrium was assumed, and Dr. Preparata noted that Dr. Schwinger of UCLA has a 3-D model of fluctuations in a lattice.

UTAH - ANNIHILATION REACTION?

Carl Jensen (Salt Lake City, Utah)

[A novel mechanism involving neutron/antineutron annihilation rather than fusion is proposed, occurring in regions of high proton density. Ed.]

This mechanism produces energy yields 2 orders of magnitude greater even than fusion (1878 MeV per event), and few particle products. It was also noted that this process is not impeded by Coulomb barriers. Finally, the energy release in the event was proposed to proceed at a slow rate, say a few microseconds, possibly leading to reactions lasting several hours. The possibility of secondary fusion reactions was noted. Neutron bombardment is predicted to increase the rate (due to decay of the free neutrons); cooling may also increase it.

CHINA - WHISKERS

X. Jiang (Langhorn U, China) and L.J. Han (Lanzhou U, China), "Theory of Micropinch".

COMMENTS

[The creation of conditions far from equilibrium, produced by a high deuterium flux at whiskers and other protrusions less than 1 micron in diameter, was suggested by Dr. Jiang as a central factor. No abstract was available. Ed.]

The enhancement of the electrical field/charge density/current density (resulting in increased electron screening) is suggested to be further increased by magnetic self-pinch of the field present during the electrolysis, possibly leading to a contraction to a degenerate state with an electron density of approximately 10^{30}/cm^3. It was also suggested that the high electrical field strength at the tip could change the branching ratio as well as the rate through polarization (such as by orienting the deuterons). In a D_2O electrolysis experiment, in which 150 nanosecond high current pulses (105 A) and a pointed Pd electrode were used, neutrons count rates of 1100 to 1500 counts/10 minutes were reported, versus <100 counts/10 minutes for H_2O controls.

PURDUE -SCREENING

Gary S. Chulick, R.A. Rice, Y.E. Kim (Purdue), "The Effect of Electron Screening and Velocity Distribution on Proton-Deuterium Fusion Rates in Physical Processes", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Recently, the electron screening effect, in conjunction with a particle velocity distribution, has been shown to greatly enhance the cross sections and reaction rates for deuteron-deuteron (D-D) and proton-deuteron (p-D) fusion at extremely low kinetic energies [Fusion Technology 18 p 147]. The p-D fusion reaction is shown to dominate other fusion reactions involving hydrogen isotopes for kinetic energies E less than approximately 8 eV in the center-of-mass frame. This indicates that p-D fusion may serve as an important source of internal energy for planetary bodies. It was suggested that the well established high $^3He/^4He$ ratio in volcanic emissions may be attributable to the reaction D(p,gamma)^{3}He occurring in the earth's mantle with a geological fusion rate of lambda$_{geo}$ approximately 10^{-24} fusions s^{-1}/D. For temperatures of 1200-3000 degrees K (k_BT approximately 0.1 - 0.25 eV), which correspond to that of the earth's mantle, our calculated values of the p-D fusion rate lambda$_{calc.}$ with reasonable electron screening models bracket lambda$_{geo}$. The conventional calculation without the electron screening effect yields values of lambda$_{calc.}$ which are astronomically small. The electron screening effect on the fusion rate for reaction D(p,gamma)^{3}He may therefore explain the high $^3He/^4He$ ratio and also provide a major source for mantle heating in the earth. The electron screening effect on p - D fusion may also provide a balance to the excess heat radiation from the gas giant planets (Jupiter, Saturn, Uranus, and Neptune), provided it is about four times stronger than Thomas-Fermi screening.

COMMENTS

[Extremely large possible enhancements due to electron screening were modeled for the d+d and d+p reactions at very low energies. Ed.]

The d+p reaction rate was modeled be greater than the d+d rate by one to a few orders of magnitude at the lowest energies. Experimental data was also presented, showing deviations of the cross-sections for other nuclear reactions from the extrapolated trend at very low energies.

PURDUE - EFIMOV EFFECT

Yeong E. Kim (Purdue), "The Efimov Effect And The Anomalous Branching Ratio For Deuterium Fusion Reactions", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

The branching ratio, R^T_{exp} [D(D,p)T]/R^n_{exp} [D(D,n)^{3}He] less than approximately 10^9 observed by Claytor et al. and others is contrary to the conventional assumption of nearly equal branching as expected from charge symmetry and the charge independence of the nuclear force, and is yet to be explained theoretically if the experimental data for the anomalous branching are definitively confirmed. After the incident deuteron penetrates through the Coulomb barrier to within an effective nuclear interaction range of 8 F (twice the deuteron radius), nuclear dynamics take over for this system of four nucleons. One possible explanation for the unequal rates is that there may be resonance behavior in sigma(E) for the reaction D(D,p)T but not in sigma(E) for the reaction D(D,n)^{3}He at low energies. This is plausible since the final state Coulomb interaction is present for the reaction D(D,p)T but not for the reaction D(D,n)^{3}He. Another possible explanation is that there may be resonances for reaction D(2D,T)^{3}He at low energies. The question of whether the anomalous branching ratio can be understood as an extension of Efimov's effect [Phys. Lett. 33B p 563] to the four-nucleon system and the three-deuteron system will be discussed. Efimov demonstrated a remarkable and hitherto unsuspected property of three-body systems by showing that if three non-relativistic identical particles interact via short-range two-body potentials gv(r), then as the coupling constant g increases to that value g_o which can support a single two-body bound state at zero energy, the number of bound states of the three-particle system increases without limit, being roughly given by the formula N = approximately (1/pi)ln(|a|/r_o), where a is the two-body scattering length (which becomes infinite whenever there is a zero-energy s-wave two-body bound state) and r_o is the range of the potential v(r). This implies that whenever there is a two-body bound state with zero binding energy, there are an infinite set of solutions of the three-body Schroedinger equation with E complex and

very near zero. Whether any of these states will be observable resonances or virtual states for four-nucleon and three-deuteron systems will be discussed in terms of (1) Efimov's effect for the (D+D) system as a three-body system, (D + p + n), (2) generalization of Efimov's effect to four-body systems, and (3) Efimov's effect for the (D + D + D) system. An Efimov or Efimov-like effect is expected to be different between reactions D(D,p)T and D(D,n)^{3}He due to different final-state interactions.

COMMENTS

[It was suggested by Dr. Kim that the Efimov effect, discovered in 1970, could provide another possible theoretical basis for low-energy multibody resonances such as d+d+d fusion. Ed.]

PURDUE - HYSTERESIS EFFECT

Y.E. Kim (Purdue), "Hysteresis Effect and Fusion Burst Phenomena in Electrolysis and Gas/Solid-State Fusion Experiments", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Practically all of the reported results of heat, tritium, and neutron generation from electrolysis and gas/solid-state deuterium-deuterium fusion experiments are burst phenomena in which fusion products have been observed intermittently in short bursts. The fusion burst phenomena observed recently by Arata and Zhang [Fusion Technology 18 p 95] and others are described in terms of a surface fusion mechanism involving hysteresis of deuterium solubility in metals as a function of metal temperature. The proposed surface fusion mechanism with the hysteresis effect suggests a temporal correlation between the metal temperature and the fusion burst phenomena, which should be measured in future experiments to test the proposed hypothesis.

COMMENTS

[A hysteresis phenomenon involving cyclic changes in the degree of loading of Pd in H_2O or D_2O, accompanied by repeatable 30 degree C temperature fluctuations, is suggested to play a role in cold fusion. Ed.]

The hysteresis cycle involves endothermic desorption of H or D, with a decrease in the Pd temperature from 110 to 80 C, followed by exothermic reabsorption, with a temperature increase from 80 to 110 C. This mechanism creates a high density of mobile deuterons in the surface layers of the Pd. Similarities to the conditions during ion implantation were noted, and it was noted that increased electron screening could result. It was also suggested that this could create conditions favorable for forming D-D or D-D-D resonances.

A test was suggested in which excess heat would be looked for in a blank experiment with hydrogen pressurized so that the hydrogen hysteresis temperature of 140 C could be reached.

PURDUE - CLAYTOR Pd+Si EXPERIMENTS

Yeong E. Kim (Purdue), "A Surface Fusion Mechanism And Optimal Conditions For Deuterium Fusion With Gas/Solid-State Fusion Devices", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Claytor et al [Los Alamos Reprint LAUR-89-39-46] have investigated deuterium fusion processes in a gas/solid-state (G/S) device with high pulsed DC voltages less than approximately 3 kV and have been successful in attaining reproducible results for tritium production from their G/S cells. Their experimental results are explained in terms of a surface fusion mechanism. Theoretical criteria and experimental conditions for improving and optimizing the deuterium fusion rates in G/S fusion devices are described in the context of the surface fusion mechanism. It is also shown that the surface fusion mechanism provides a plausible explanation for the non-reproducibility of results in electrolysis fusion experiments. In contrast to the shortcomings of electrolysis fusion cells, the G/S fusion cells are stable and physically controllable for each and every experiment, and thus the G/S fusion device offers a desirable and promising system in which experimental conditions for optimizing deuterium fusion rates can be investigated with reproducible results. The use of a high pulsed DC voltage of less than approximately 100 kV in the G/S fusion device may provide economical tritium production and may lead to practical applications for large-scale power generation.

COMMENTS

[Calculations suggested that enormous gains in tritium production in the Claytor Pd-Si-D experiment might be possible at higher voltages. Ed.]

PURDUE - WADA HV EXPERIMENTS

Yeong E. Kim (Purdue), "Neutron Bursts From High Voltage Discharge Between Palladium Electrodes in D_2 Gas".

ABSTRACT

Recently, Wada and Nishizawa [Jap. J. Applied Phys. 28, p L2017] reported a burst of neutrons from the stimulation of D_2 gas by a high AC voltage (12 kV, 60 Hz) discharge in a closed glass bulb between two palladium electrodes which were loaded with deuterium to a maximum value of 1/3 for the D/Pd ratio. The observed neutron counting rate R^n_{exp} of 692 counts for a duration of 63 seconds or R^n_{exp} approximately 11 cps immediately after the beginning of the high-voltage stimulation lasting 540 seconds is about $2X10^4$ times larger than their neutron background counting rate of R^n_{bg} approximately 5.5×10^{-4} cps or approximately 2/hour. They interpret this neutron burst as due to fusion events in terms of the supersaturation of the solid solution of deuterium. An alternative explanation of their experimental results, which is less speculative and more plausible, is given in terms of known values of the experimental cross-section for deuterium-deuterium (D-D) fusion. Theoretical criteria and experimental conditions for improving D-D fusion rates in the device of Wada and Nishizawa with the use of pulsed high DC voltages are described. It is shown that the use of pulsed high DC voltages and high D_2 gas pressure can increase the total D-D fusion rates by many orders of magnitude.

JAPAN - NATTOH MODEL

T. Matsumoto (Hokkaido Univ., Japan), "Progresses of NATTOH Model and New Particles Emitted During Cold Fusion", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Progresses of the NATTOH model and related experiments are described.

In the NATTOH model, the cold fusion is based on the hydrogen-catalyzed fusion reactions, in which the word "catalysis" has double meanings: intra- and inter-clusters. In the former, new "iton" particles are emitted which take away excess energy of fusion and close channels for emitting neutrons and tritium. The latter makes chain-reactions possible which have two loops: direct and indirect.

Related experiments have been made to make clear the mechanism of the cold fusion. New particles "iton" and "quad-neutron" have been observed. Especially important, micro-explosions have been recorded. This fact opens new aspects to the cold fusion that the cold fusion is a small scale simulation of events which take place in the last period of stars far in the universe and that not only the fusion energy but also the gravitational energy will be available.

1. Progresses of NATTOH model
   a. Concept of hydrogen chain-reactions
   b. Fundamental equations
   c. Critical equation for indirect loop
   d. Time-behaviors of power
   e. Prediction of new iton particles

2. Related experiments
   a. Observation of new iton particles
   b. Microscopic observations of Pd
   c. quad-neutrons and gravity decay

COMMENTS

[The model proposed involves chain reactions to form novel particles. In addition, unusual tracks seen in nuclear emulsions, which could represent these or other novel particles, were shown which appeared interesting in their own regard. Ed.]

Additional deuteriums in the reaction both cause sufficient aggregation to allow fusion and carrying off sufficient kinetic energy to undergo further reactions. Various possible products such as ^{4}He and ^{6}Li are considered. A nonlinear rate term is proposed to lead to a power output which rises to a spike, drops off again, and asymptotically rises to a plateau.

In the emulsions, sets of several tracks radiating from a single point are taken as evidence of "itons', and circular features of "microexplosions".

PREPARATA - COHERENCE & FRACTOFUSION

Giuliano Preparata (National Cold Fusion Institute and U of Milano, Italy), "Fractofusion Revisited".

ABSTRACT

The well-known phenomenon of high energy particle emission from newly-created fractures in solid materials is seen to have a natural explanation in terms of the ponderomotive forces exerted by the coherent e.m. fields associated with the "superradiant" motions of the charged plasmas of solids. The possible role of these fields to produce the neutron bursts that have been recently observed concomitantly with "crack" formation in Ti-deuterides is briefly discussed.

COMMENTS

[A superradiance phenomenon and coherent electromagnetic fields are invoked. Ed.]

Dr. Preparata noted the early suggestion of fractofusion in the mid-1980s by Russian groups, and the observation of fractoemission of negatively and positively charged particles (presumably electrons and ions) and electromagnetic radiation since WWII in very strongly stressed solids subsequent to mechanical creation of cracks and voids. (Electron energies up to tens of KeV were reported by V.V. Karassev, N.A. Krotova and B. Deryagin, Dokl Akad Nauk SSSR 88, p 777, 1953, associated with cracks at metal-polymer interfaces. Electrons with energies up to 200 KeV were reported by Kluyev, Dokl Akad Nauk SSSR 279, p 415, 1984, in LiD, with the suggestion that accelerated deuterons colliding with stationary deuterons could be undergoing d-d fusion. Neutrons were also reported by V.A. Kluyev et al, Pisma Zh Tekh Fiz 12, p 1333, 1986.)

Dr. Preparata questioned whether we understand this, and suggested it could be important for cold fusion. Although evidence for charge separation at cracks, such as radio emission, was also seen, it was suggested that electrical fields of 10^{6-7} V/cm were too large to be reasonable, nor was emission for up to 2 hours. Instead, superradiance was suggested as an explanation; Dr. Preparata also referred to Dr. Rafelski's work on coherent electromagnetic fields, and indicated that his usage of superradiance was not completely identical to Dicke superradiance. As a reference, G. Preparata, Quantum Field Theory of Superradiance, in Problems of Fundamental Physics, R. Cherubini, P. Dal Riaz and B. Minetti, eds, World Scientific (Singapore) was cited, along with the paper by Preparata presented at the First Annual Conference in Salt Lake City.

According to this model, nuclei and electrons undergo plasma oscillations in phase; the coherent EM field is trapped (totally reflected) inside the plasma. At the interface between the plasma and vacuum, however, an evanescent EM wave spills over, with an exponential decay with distance.

In addition, ponderomotive forces produced are hypothesized to cause enhancement of Coulomb barrier penetration; an analogy was made to laser physics. The charge separation is explained as a consequence of the strong mass dependence of this force, created concomitant with crack formation but not the cause of the fusion. The energy imparted is on the order of 20-40 eV.
In the subsequent discussion, extension of the theory from metals to dielectrics (i.e. deuterides) was debated.

EPRI & PURDUE - CLUSTER IMPACT

R.A. Rice, G.S. Chulick, Y.E. Kim (Purdue U) and M. Rabinowitz (Electric Power Research Institute, Palo Alto CA), "Cluster-Transport Impact Fusion", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Recently, Beuhler et al [Phys. Rev. Lett. 63 p 1292] measured deuterium-deuterium (D-D) fusion rates in a series of experiments in which singly-charged clusters of D_2O molecules ($[D_2O]^+{}_n$, n = 25 - 1300) accelerated to 200 to 325 keV (a beam current of approximately 1 nA) were incident on TiD, $(C_2D_4)_n$ and $ZrD_{1.65}$ targets. Their observed D-D fusion rates are more than 10^{25} times larger than the conventional estimates [Rabinowitz, Mod. Phys. Lett. B4 p 665; Kim, Fusion Technology 17 p 507] expected for deuterons of the same velocity. Several theoretical models [such as Echenique, Phys. Rev. Lett. 64 p 1413] have been proposed to explain the discrepancy of 10^{25} but fail to reproduce the observed fusion rates by many orders of magnitude. More recently, Fallavier et al. [Phys. Rev. Lett. 65 p 621] carried out similar experiments using pure deuterium clusters (approximately $D^+{}_{200}$ - $D^+{}_{300}$) with kinetic energies of 100 - 150 keV in the same range of incident energy per deuteron (approximately 400 eV - 750 eV) and observed no D - D fusion events. Their upper limit for the fusion rate is more than one order of magnitude below the observed value of Beuhler et al.

Both the positive and the negative results of these recent cluster-beam fusion experiments are explained by a cluster-transport impact-fusion model involving a local Maxwell-Boltzmann distribution for the Boltzmann transport equation in the lowest order approximation. Calculated results indicate that the total deuterium-deuterium fusion rates can be enhanced by many orders of magnitude by the use of deuterium-heavy atom cluster beams. A set of experimental tests are proposed to probe thermalization processes for the cluster-transport impact fusion.

COMMENTS

[Dr. Rabinowitz described the use of conventional means, involving the energy escalation possible for a fraction of the molecules due to Rutherford backscattering, to explain the D_2O-cluster bombardment results reported by Beuhler et al. Ed.]

In the data, a maximum of 4 fusions per 10^{10} cluster impacts were reported at 200-250 molecules per cluster and only slow decreases for larger clusters.

The probability of a deuteron first backscattering off a Ti atom and then backscattering a second time off an O atom (so that it is traveling in the forward direction again but has gained energy) is calculated as 0.004. This is sufficient to represent a very significant raising of the tail of the Maxwell-Boltzmann distribution. (The probability of a deuteron undergoing multiple cycles, however, drops rapidly.)

As noted, the predictions of this model were also consistent with the negative results then being found by Fallavier et al, using an ion beam not containing oxygen (D_2 rather than D_2O), and with the fact that Beuhler found only minor differences due to the type of target. It was also noted that among the predictions that could be made for experiments not yet conducted, this model would predict much less fusion if the target is D_2, and particular conditions in which $(D_2)_n$ impacts could yield the same fusion rate as $(D_2O)_n$.

Apparent errors in previous calculations were also discussed; it was stated that both Beuhler et al and Echenique et al appeared to have incorrectly used the laboratory rather than center-of-mass frame of reference in expressing the deuteron energy in their calculations of the expected rate of conventional fusion, leading to an underestimate of the rate by a factor of 10^{12-13}.

Although a low-energy Bright-Wigner resonance was also mentioned as another possible explanation, it was noted that such a resonance would need to be very narrow in order to be seen at 500 eV but not at 3 KeV.

ARIZONA - THEORETICAL PROSPECTS

J. Rafelski (U of Arizona), "Theoretical Prospects for CCF: Conventional Cold Fusion", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

One of the first steps towards the understanding of the "background" rate of fusions in a hydride is the understanding of the static mean interaction potential between the hydrogen nuclei. It was quickly realized that diverse static condensed matter effects have great influence and hence the two body fusion rate is greatly enhanced. The key conclusion of quantitative studies is that even a very substantial but justified modification of the Coulomb barrier will result in fusion rates that are many orders of magnitude too small to be observed.

About a year ago the attention has turned towards the possibility that a new elementary particle, or perhaps complex systems made of known particles, of negative charge *e*, could catalyze fusion reactions. While there are attractive experimental aspects of this hypothesis related to the sporadic reports of fusion activity and possibly their space localization in materials, presence of such new objects is strictly putative. However, if stable, negatively charged (ultra-heavy) objects exist, cold catalyzed fusion will be the source of power in the next century.

Conventional Cold Fusion (CCF) must be a quantum process, far away from the classical limit. Especially in a near degenerate condensed matter environment a theory must allow for *many body non-equilibrium quantum phenomena.* Yet nearly all serious estimates of fusion rates are based on classical two-body free-space reactions. Such an approach is even not correct in static estimates of the fusion rate: despite the fact that individual deuterons are 'classical' objects, a part of their amplitude is in quantum domain (else they could not fuse at all) and the question arises about the coherence of the small quantum tails of the N-body wave function. This issue is greatly amplified when nonequilibrium phenomena are involved, as a major share of the flow energy can in principle be directed into these quantum components. Only a non-equilibrium study of what experts would call *dynamic quantum - two-plasma model in harmonic time dependent lattice potential* can provide the ultimate theoretical answer about fusion in condensed matter. *Work supported by the US-DoE/BES-AEP.*

COMMENTS

Dr. Rafelski began by mentioning the variety of approaches which have been used by cold fusion theoreticians. "Conventional" approaches have involved electron screening, both static (ex. Zakowicz) and dynamic (ex. Belyaev and Danos), pressure / confinement (ex. Jandel), and mean kinetic energy, both temperature effects (ex. Gajda) and fractions (ex. Preparata). "Wishful" approaches included 3-body interactions such as d+d+d -> ^{3}He + t (each with 4.8 MeV kinetic energy), interactions involving leptons (electron, neutrino capture), and methods to borrow kinetic energy from lighter particles (by going off the mass shell). "New physics" approaches included new particles (ex. Rafelski and Shaw), new or modified interactions (ex. modifications to the Coulomb interaction), and new many-body physics in solids (ex. Preparata). Lastly, "virtual kinetic energy" was listed.

It was pointed out that, given that an energy scale on the order of 10 eV is involved when hydrogen molecules dissociate and enter the lattice, the probability of deuteron kinetic energies of say 100 eV was worth considering, since the Jones cold fusion rate could be explained by 1 part in 10^{10} of the deuterons having energies on this order (as could screening radii on the order of 0.1 A). [However, in subsequent discussion, it was suggested by Dr. Kim that the energy scale of deuterons in the lattice was more nearly on the order of 1 rather than 10 eV.]

If, instead, the explanation involves new particle catalysis, certain requirements must be met: a stable, inactive form must exist, yet activation (release of the catalytic particle) must be relatively easy, such that active forms such as Xd or Xdd are formed in the presence of deuterium even in such low-energy environments. It is suggested that the only clear solution is a stable, negatively charged particle (which can therefore exist as, say, neutral XD or X^4He). A paper by Bigeleisen in Physical Review Letters was cited showing limits on yet-undetected particles; it was noted that catalytic particles with masses > 10^3 GeV and average abundances < 10^{-20} per nucleon could still exist.

Two significant items of experimental evidence were also noted. First, it was pointed out that simple calculations or the TRIM program show that a significant fraction [up to 1 in 10^{-3} to 10^{-5}] of products such as tritons should undergo secondary reactions unless their kinetic energies are much less than 1 MeV, or unless other products such as ^4He are formed instead. Second, the apparent need for a flow of hydrogen suggests that nonequilibrium processes be modeled.

GERMANY - PLASMA MODEL

Dieter Seeliger & Andreas Meister (Dresden U of Technology, Germany), "A Simple Plasma Model for the Description of dd-Fusion in Condensed Matter", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT (Paper not presented)

A simple plasma-like model for the description of the time behavior of the dd-fusion reaction rate as a function of charging time is presented. Its application to the description of experimental dd-neutron production rates averaged over broad time intervals gives reasonable agreement. The fusion rates obtained from this comparison are in the order of magnitude of effects, which could be expected by the combination of electron screening and fluctuation enhancement. The model allows predictions under which conditions dd-fusion neutrons in condensed matter could be observable and provides an explanation, why in many cases no effects are observed.

UC IRVINE & ITALY - QUARK CATALYSIS

Luciano Fonda (International Center for Theoretical Physics, Trieste, Italy) and Gordon L. Shaw (U of California, Irvine), "Fluctuations and Nonreproducibility in Cold Fusion from Free Quark Catalysis", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

It is now more than a year since Fleischmann and Pons, FP, announced the astonishing (and rather premature) claims of watts of power from cold d+d fusion without large amounts of radiation. This gave rise to a flurry of experiments trying to reproduce or investigate the claims of FP: most of them were completely negative; some saw some bursts of neutrons or some power produced for short periods of time. Further discouragement came from the lack of viable theoretical scenarios for the cold fusion phenomena. Although most scientists are convinced that there was no cold d+d fusion observed, there remain some observations which make the final conclusion to this problem uncertain (perhaps due to the staggering importance of a positive result), and further we suspect there are experimenters investigating this problem around the world who are now being extremely cautious in announcing any positive results. The purpose of this contribution is to summarize the recent publication [Shaw et. al, Il Nuovo Cimento 102A, p 1441 (1989)] presenting a scenario for cold fusion catalysis by free Q anti-di[mu]quarks. Our Q catalysis scenario is consistent with conventional physics, would explain the non-reproducibility and fluctuation in these experiments, and gives testable predictions.

We recently point our that free stable Q's (electric charge of 4/3, mass greater than some fraction of a GeV, and short-range strong repulsion with hadrons) could rapidly (at a rate of 10^{10} per sec per Q) catalyze d+d fusion with the reaction channel He^4 dominating. The existence of such free, stable Q anti-diquarks is provided by the glow model of spontaneously broken QCD and the number of such Q's (left over from the big bang) necessary to explain the fusion reports is consistent with present experimental limits on the non-observation of free fractional charge.

The d+d cold fusion reactions catalyzed by the Q's are:

$(Qdd)_{molecule}$ --->
(i) $He^4 + Q + 23.9$ MeV,
(ii) $He^3 + n + Q + 3.3$ MeV, or
(iii) $T + p + Q + 4.0$ MeV.

Note that the charge -4/3 of the Q is crucial in the rapid formation of the (Qdd) molecule which is the limiting time in this catalytic cycle. We predicted that:

(1) Due to the strong hadronic interaction of the Q, the Q is not a spectator as would be the case for muon-catalyzed fusion. Thus we found that the two-body He^4 channel (i) is strongly favored with respect to the three-body neutron (ii) and proton (iii) channels by a factor of R about $10^6 \{m_{int}\ (GeV)\}^2$, where m_{int} is the relevant strong interaction mass for the final state interaction.

(2) The neutrons produced from the n channel (ii) obey a three-body energy spectrum instead of having the fixed energy 2.45 MeV (as for the two-body reaction d + d --> He^3 + n).

(3) Bursts of neutrons, localized in time, should emerge out of the deuterated transition metal electrode.

Prediction 3. comes rather naturally from the fact that when a nonequilibrium process releases a Q, perhaps from a hydrogen-like "quarked" He^4Q atom, inside the transition metal electrode (e.g., mechanical cracking occurs during the later stages of hydration) the Q will cause the catalytic reactions (i)-(iii) until it eventually gets trapped on a deep energy level of a heavy atom or escapes from the interaction region.

Thus it is clear that in this Q catalysis scenario many factors can play a role, e.g., the metallurgical preparation of the transition metal electrode could determine the initial Q concentration; the physical thickness of the electrode and the deuterating recycling previous history will play roles in depleting the available Q's for liberation.

We conclude by emphasizing the importance that these Q's could have in catalyzing cold fusion, and providing a large energy source with relatively low radioactivity if these type of particles are not confined and can be accumulated. Thus renewed interest in high sensitivity bulk matter searches for free fractional charge seems warranted.

COMMENTS

[Dr. Shaw's presentation suggested that the mechanism of cold fusion may involve catalysis by anti-diquarks to produce ^4He. Ed.]

It was noted that the concentration of such Q particles necessary, less than 1 per 10^{19} baryons, is consistent with failure of experiments to date to detect fractional charges, but suggested that the concentration of the latter may be only 1-2 orders of magnitude below the present level of sensitivity. It was also suggested that Q particles bound to He could have a similar affinity as hydrogen which would lead to their concentration in certain transition metals.

Predictions include bursts consisting predominantly of alpha particles (^4He), but also including some (3-6 orders of magnitude fewer) neutrons and protons, in which the alpha particles have fixed energies but the neutrons and protons would have ranges of energies. The alpha particle energy would depend on the mass of the Q particle; it would be 5 MeV if the Q mass is 1 GeV, or 8 MeV for 2 GeV Q's.

It was noted that if this mechanism is correct and collection of Q particles in liquid deuterium is possible, each untrapped Q should generate 0.02 W of continuous power.

BROOKHAVEN - COHERENT MOTION

Hiroshi Takahashi (Brookhaven National Laboratory), "The Role of Coherency on D-D Fusion Reaction in PdD_x Deuteride", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

To get a kinetic energy required to produce d-d fusion and to dissipate the excess nuclear energy to Pd lattice motion in PdD_x deuteride, the coherency of the Pd lattice motion plays an important role. A number of elementary processes of exciting phonons which are participating in the coherent motion is extremely large, thus making it hard to solve the simultaneous equation of motion for the many phonon excitation states. By describing the coherent state as classical mechanics, the formulation becomes more simplified and becomes manageable. The cause of the coherency in PdD_x deuteride, and the analogy to the theory of Fermi's statistical acceleration, will be discussed.

COMMENTS

[Coherent behavior in a lattice was suggested as an explanation for how measurable reaction rates could be possible even though lattice vibration energies (typically on the order of 0.1 eV) are quite a few orders of magnitude less than the energy barrier in conventional fusion. Ed.]

It was noted that Drs. Hagelstein and Schwinger had previously presented models which suggested that the kinetic energy from the reaction could be coherently absorbed in the lattice. Also, data published by Dr. Meyerhof, showing energy levels in various nuclei, was noted, and it was suggested out that the extreme n/t branching ratio could be accounted for by a d-d reaction mechanism involving an excited state whose energy was above that for t+p but below that for ^3He+n.

The possibility of coherent acceleration of deuterons during alpha-beta phase transitions in Pd deuteride was considered, and a nonlinearity in the mechanism was suggested as a cause of burstlike behavior.

ITALY - PHASE TRANSITIONS

Eugenio Tabet (Physic Lab NIH, Rome, Italy) and Alexander Tenenbaum (La Sapienza U, Rome, Italy), "Developments of a Dynamical Model for Cold Fusion in Deuterated Palladium", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

We have developed a dynamical model which accounts for cold fusion processes in deuterated palladium exposed to a steep thermal transient. The thermodynamic instability induced by such transient gives rise to a deuteron drag which enhances the nuclear reaction rate (Phys Lett A, 144, p 301, 1990). The deuteron drag process has been analyzed in a self-consistent way in the framework of a pseudo-plasma treatment of the deuteron population. An explicit numerical computation of the nuclear reaction yield is given as a function of two relevant thermodynamical parameters of the metal-deuterium system (concentration and temperature). Finally, we present some comments on the time evolution of the instability.

COMMENTS

[The theory presented by Dr. Tenenbaum models the concentration of elastic energy released during Pd deuteride phase transitions in small areas and its transfer to the deuterons in the lattice, leading to conventional d-d fusion. Ed.]

It was noted that while alpha and beta deuteride phases with quite different deuterium concentrations can coexist below the critical temperature [approximately 300 C], only the beta form exists above it. Thus, if the temperature is dropped from the 1-phase to the 2-phase region, an unstable condition will be created. Two sets of regions with different lattice parameters will form, deuterons will migrate from the low- to the high-concentration phase, and elastic energy will be redistributed and may be released. (The effect would be different in the reverse transition.)

The transition is modeled to occur in spherical regions, with the maximum size of the regions and the resulting change in potential energy depending on the change in the lattice parameters- the regions can become larger if the change is lower-energy. It is hypothesized that in the formation of the low-concentration regions, the elastic energy is released in a coherent way, with the whole region collapsing inward together. (The typical size of a region is estimated to be approximately 30 lattice parameters.)

In deuterated metals, it was also noted that the Gorski effect could lead to an inward current in such conditions, raising the concentration of deuterons in the inner region ("deuteron drag"), and that concentration gradients could also contribute to the inward deuteron flux. Modeling of the approximate number of deuterons migrating inward, and their average kinetic energies, suggests that it may be possible to get conventional nuclear reactions even at low initial deuterium concentrations. For example, at 77 K, it was indicated that even with an initial loading of only .001, it might be possible to locally reach supersaturated conditions during the phase transition.

Calculations of conventional fusion rates were made, based on extrapolation from thermonuclear fusion rates and assuming a Maxwell-Boltzmann velocity distribution with maximum predicted deuteron kinetic energies of up to a few KeV. In a calculation of the maximum rate possible, if all elastic energy could be converted to kinetic energy, the yield at 77 K was $3.5X10^6$ neutrons per mole of Pd, with the maximum occurring for an initial D/Pd loading of 0.1. The yield for the reverse transition (to higher temperatures) was less, and the maximum occurred for high initial loading.

More realistic calculations using 2% and 10% efficiency for the conversion of strain energy to deuteron kinetic energy were also performed at both 77 K and 273 K. The optimum loading at 273 K in the example shown was higher than at 77 K. Also, the yield was 25 times less than at 77 K, since thermal motions at higher temperatures can prevent coherent collapse of large regions. (The energy barrier the outer atoms have to overcome is very small.) At 2% efficiency, the optimum concentration range became very narrow (and corresponded to lower loadings), leading to less reproducibility. The yield for the reverse direction was also sensitive: in a sample calculation at 10% efficiency, the yield was 300,000/mole at an initial loading of 0.72, but dropped to zero at a loading of 0.73.

It was reported that the model's quantitative predictions were currently being tested in Italy. In the subsequent discussion, the possible existence of a similar mechanism for Ti was raised.

EGYPT & ITALY - SCREENING

M. Vaselli, V. Palleschi, M.A. Harith (Cairo U, Egypt), G. Salvetti and D.P. Singh (Istituto di Fisica Atomica e Molecolare, Pisa, Italy), "Explanation of High D-D Nuclear Fusion Rates in Metals at Low Temperatures", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT (Paper not presented)

Many experimental studies have demonstrated the possibilities of the occurrence of very high nuclear fusion rates between deuterium ions absorbed in metals at low temperatures in the recent past. On the other hand, various attempts have been made to introduce a "pseudomass" and "pseudocharge" for electrons to form a more tightly bound hydrogen molecule to undergo fusion similar to muon-catalyzed fusion, however no plausible mechanism for the enhancement of electronic mass/charge has been presented so far. The aim of this paper is to present, within the framework of a plasma model, a realistic estimate of the inter-ionic potential involving electron screening of ion impurities in palladium metal [Nuovo Cimento 11D(6) p 927] and the short range ion correlations between such ions, that may account for the experimentally observed fusion rates at low temperatures. However, till now it is not clear how many of the 46 electrons surrounding the Pd nucleus can effectively contribute to the screening of deuterium ion potential. Hence, it has been considered a free parameter in the present work. The radial profiles of the bare Coulomb potential and the effective potential incorporating electron screening and the deuterium ion correlations are plotted. The dependence of nuclear fusion rate per D-D pair on the ion temperature and on the number of electrons per Pd atom contributing to the screening has been presented. It is seen that the experimentally observed fusion rate (approximately 10^{-23} fusion events per D-D-pair per sec) can be explained if at least approximately 30 out of the 46 Pd electrons may contribute to the deuterium ion screening.

USSR - CAVITIES AND CRACKS

V.I. Vysotskii (Kiev State U, USSR) and R.N. Kuz'min (Moscow State U, USSR), "The Theory of Nonthreshold Cold Fusion in Solids.", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

INTRODUCTION

[No abstract was given, but the following is the introduction to the authors' paper.]

In our articles, the theory of controlled nuclear synthesis for charged particles under a dynamical regime was constructed. The main ideas of this theory are connected with a drop or breakdown of the Coulomb barrier for target atoms due to spatial averaging under oriented motion of deuterons (d) or tritons (t) in the lattice. Much attention [in these articles] is given to optimization of the nuclear reaction (d-d, d-t) for a drop or breakdown of barriers for the LiD compound.

In this note, we propose a simple model for the quasistatic situation which suggests that cold fusion of deuterium atoms occurs without a rapid transfer of particles. In this case the reason for a breakdown of barriers in the external (quantizing the motion of particles) field of force (for example, the potential energy of the hole walls - analogous to 3-dimensional quantum hole; or crack with undetermined boundaries - analogous to 1-D, 2-D quantum hole). A similar mechanism of a breakdown of barriers is found in a helium atom when the Coulomb interaction with a nucleus cancels the repulsion of electrons.

In a quantum system consisting of N deuterons and a hole barrier confluence, atoms breakdown under the condition:

V_{de} >> E_{nm} >> $<V_{dd}> \equiv$ <<< Sum_j V_{dd} (vector r_i - vector r_j)$>_{spin}>_{ri}>_{rj}$

where $<V_{dd}>$ is the average energy of the (d-d) interaction; V_{de} = 13.6 eV is the interaction energy of deuteron in a deuterium atom with its own electron; E_{nm} is the energy difference of the levels in the quantum system - hole or crack. Averaging is done for dimensional and spatial variables.

The first term of the inequality makes it possible to independently consider atoms of deuterium and to use the perturbation theory with independent wave functions for all particles (the second term of the inequality). [The authors note that by making use of the theory of the interatomic H-H or D-D interactions with allowance for Coulomb spin and dispersion forces with potential V_{dd}(vector R_1 - vector r_2) it is possible to demonstrate that the value of $<V_{dd}>$ is computable and equal to zero under specified conditions.]

COMMENTS

[Dr. Vysotskii proposed high rates of fusion among deuterons trapped in a potential well created by a bubble or hole a few A across, or in a crack, and suggests that this mechanism could also account for bursts occurring at intervals. Ed.]

ARIZONA - COUPLED REACTIONS; RESONANCE

W. Zakowicz and J. Rafelski (U of Arizona), "Low Energy Nuclear Resonance and Cold Fusion", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

The hypothesis that the existence of an ultra low energy resonance in the d-d system could assist fusion is considered quantitatively. The presence of the nuclear

threshold resonance would be a consequence of rather coincidental relation between the nuclear and Coulomb interactions between two colliding deuterons. In the resonant conditions the probability of penetration of the Coulomb barrier is enhanced. A schematic, potential based model of the nuclear reactions coupled to the d-d fusion channels as shown in Figure 1 is described, which permits an assessment of the exact magnitude of the fusion reaction cross section at ultra low energies in presence of screened Coulomb d-d repulsion. Our results for the reaction efficiency are presented. We can find an enhancement by about 10 orders of the magnitude for low energies. However, this resonant cross section does not match well the experimental data at accessible energies, E > 10 keV. Once our model parameters are adjusted to experimental data there remains little sign of a resonant reaction process.

In the process of obtaining this result we resolve a long-standing discrepancy between the $1/v^2$ behavior of the Gamov astrophysical reaction formula for the lowest energy fusion cross section, and the general quantum mechanics inelastic reaction result (Bethe's law) which requires 1/v behavior of all reaction cross sections in the limit v --> 0. In particular, we determine at which energy there is a significant deviation from the astrophysical Gamov formula due to onset of the Bethe's law. We stress that the considerations in this note will be strictly limited to the reactions of *two deuterons*; however, recognizing the importance of Debye-Huckel screening for lowest energy reactions, we also modify the d-d Coulomb repulsion potential by a static (exponential) screening. This is a token acknowledgement of the fact that numerous other many-body processes could and will stimulate fusion rates in dense matter. A full investigation of the many-body phenomena is required in order to clarify the theoretical issues related to ultra-low energy two-body fusion reactions at low energy. {Work supported by the US DoE/BES-AEP}

COMMENTS

[In the presentation by Dr. Zakowicz, two possible models for low-energy fusion were considered, involving coupled nuclear reactions and very-low-energy resonances. Ed.]

The first model involves 3 interacting and mutually coupled channels: d+d, n+^{3}He, and p+t fusions. Since the neutron has no Coulomb repulsion, such reactions would be possible in a coupled system, and the energies of the neutrons and tritons would be predicted to be higher than normally expected.

In the second model, it was noted that the degree to which a resonance would be spread out over the entire low-energy range would depend on the strength of the coupling to the other channels. However, as noted, taking higher-energy data and inverse reactions (p+t-->d+d, etc) into account, the best fit to the data involves no resonance, suggesting investigation of multibody rather than 2-body effects may be the more productive approach.

In subsequent discussion, Dr. Kim pointed out that 3-body collisions would be more reasonable in 1-dimensional channels created in lattices or in implantation experiments than in conventional fusion.

G. MISCELLANEOUS PAPERS

NCFI - ELECTRODEPOSITION OF PdD

Zhong-Qun Tian, Steven C. Barrowes, Haven E. Bergeson (National Cold Fusion Institute, U of Utah), "Attempt To Confirm The X-Ray Radiography Results Reported By S. Szpak, et al *", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

The technique of Szpak for obtaining x-ray radiographs from working electrolytic cells has been followed, in order to confirm his results. Each experiment was run with two cells, one with light water and one with heavy water, to verify that the nuclear difference was crucial to any observed effects. Szpak's technique, if confirmed, offers the possibility of obtaining the energy spectrum of emitted X-rays.

*S. Szpak, et al., San Diego, "On the Behavior of Pd Deposited in the Presence of Evolving Deuterium" (submitted for publication)

COMMENTS

[The presentation by Dr. Barrowes described a novel Pd electrolysis method described by Dr. Szpak (Naval Ocean Systems Center, San Diego) which minimizes the time required, and partial replication of the experiment at NCFI. Ed.]

The method involves deposition of Pd deuteride from solution onto a cathode; Szpak's autoradiography data gave clear evidence of X-ray emission localized in the cathode within 1/2 day or less of the start of electrolysis, with high reproducibility, as well as tritium production.

The Szpak experiment used a Ni mesh cathode and Pt anode. The electrolyte was 0.3 M LiCl and 0.05 M $PdCl_2$ in D_2O. Deposition of Pd deuteride on the Ni mesh by the current was used to avoid the long wait frequently found to be necessary in conventional electrolysis experiments; in this experiment high loading occurs at the outset. [In addition, no strains, defect formation, phase transitions, etc. due to the loading should be expected. Ed.]

The X-ray film used (4 mils thick, sealed in a water- and light-tight polyethylene envelope and covered with an additional 1 mil of polyethylene to avoid contaminating the solution) is sensitive to X-rays with energies greater than 3 KeV. (The film was tested by exposing it to light in the laboratory for 3 days; no fogging occurred.) After several hours of electrolysis, the film in one cell showed a clear image of the Ni mesh (in fact, a double exposure, as the film had moved). Thus the cathode was apparently acting as an X-ray source. The films from the other 6 cells, although not showing images, were darkened. No effect was seen with a H_2O control cell run simultaneously and in series with the D_2O cells.

In addition, subsequent analysis at NCFI showed average tritium levels of 200 dpm/ml in the electrolyte (versus 27 dpm/ml for the blank).

In the preliminary NCFI experiments, no noticeable darkening has been found to date, and tritium increases, although quite a few standard deviations above the controls, have typically been much smaller (8-10 dpm/ml). The experiments are continuing.

In subsequent discussion, it was noted that image formation would require a minimum separation between the cathode and film; in the Szpak experiment the wires in the Ni mesh were only approximately 1 mm apart, but the film was less than 1 mm away. It was also noted that cleaning of the cathodes in the NCFI experiment would have introduced some hydrogen into the cell, leading to a mixture of H and D.

ITALY - NEUTRONS, TRITIUM

D. Gozzi and P.L. Cignini (Universita "La Sapienza", Rome, Italy), S. Frullani, F. Garibaldi, F. Ghio, M. Jodice and G.M. Urciuoli (Istituto Superiore di Sanita, Rome, Italy), "Neutron and Tritium Evidences in the Electrolytic Reduction of Deuterium on Pd Electrodes", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

In a ten-cell electrochemical system a Fleischmann and Pons-type experiment was carried out which lasted about three months.

All the cells were connected in series and electrolysis was performed in galvanostatic mode at a maximum current value of 2.5 A corresponding on the average to 500 mA/cm^2. The ten cells were placed in a perspex water-cooled toroid positioned at 36 degrees one from the other.

In the centre of the toroid a He^3 neutron detector (efficiency = 5 X 10^{-5}) was inserted and two gamma-ray detectors, NaI(Tl) monocrystal and Ge(Li) were tangentially placed externally to the toroid in a diametrically opposite side.

A dedicated data acquisition system (Maestro from Ortec) was connected to both the gamma-ray detectors in such a way as to store the results at programmed time intervals.

Tritium was systematically measured in each cell by sampling small volumes of the electrolyte. Tritium was also measured on recombined gases. In both the cases, tritium was measured by the technique of the liquid scintillator according all the standard procedures routinely followed in this type of measurement. We carried out about 350 tritium tests.

In this experiment all cathodes were made of Pd and anodes were made of 1 mm Pt wire wounded as a cylindrical coil. In nine cells out of ten, cathodes were shaped as a parallelepiped (25 x 5 x 5 mm^3) obtained by high vacuum sintering according to the procedure reported in our first positive experiments [Nuovo Cimento 103A, p 143, 1990]. The starting material for all these electrodes was Pd sponge powder (Johnson & Matthey) sieved from the same batch in such a way as to obtain powder with grains smaller than 105 micrometers. The other cathode was obtained using 32 short 0.5 mm diameter Pd wires, gold-welded together at one end. In each wire a similar concentration of screw dislocations was produced. Three different groups of sintered cathodes were used in the experiment corresponding to three different sintering procedures.

On the top of each cathode a K-type thermocouple, encased in a stainless steel shield, electrically insulated from the thermoelement and used as the current lead, was welded.

All the reference electrodes were 0.5 mm Pd wires and positioned very close to the cathodes. Nine cells out of ten contain 0.2 M LiOD in D_2O as electrolyte. The other cell, containing one of the sintered cathodes, was in 0.2 M LiOH in H_2O.

An automatic system in each cell allowed heavy or light water refilling in such a way as to maintain constant the initial volume of electrolyte (31 ml).

The experiment started on March 15th, 1990, and it was stopped on June 10th. The applied current density was step-changed and for the first two months of the experiment was gradually increased. When the current density reached the highest values, we observed a marked increase of the neutron detector counting rate with respect to the background level (2 counts/h). The pattern of the emission was burst-type. The waveform shape of the signals were monitored but not stored. Both noise-like and charge-like signals were seen in time intervals, grouped in some minutes spaced even of a few hours.

This behavior was observed for about ten days but only when the current density was set over 320 mA/cm^2.

In the first part of that period, we found in three cells out of nine (one of the ten cells was in light water) an excess of tritium with respect to the expected value calculated for the electrolytic enrichment. This excess was about two times if considered with respect to the enrichment and about 4 times with respect to the initial tritium content in the heavy water (267 dpm/ml). The other cells, included that in light water, did not show any excess of tritium, the value of which was in good agreement with the calculated value.

Some aspects concerning the thermal behavior of the electrodes will be also shown.

COMMENTS

[This presentation by Dr. Gozzi described detection of unidentified particles during Pd electrolysis. The use of sintered electrodes from a single batch of fine powder, in order to control for spot contamination of tritium in the electrode, is very interesting. Ed.]

The neutron counter in this experiment measured significant bursts (maximum > 0.3/sec) lasting for up to 6 hours. However, as the pulse shapes (recorded with a digital storage oscilloscope) were different than those seen for the background counts or counts from an Am-Be calibration source, they did not appear to be due solely to neutrons. The counter had previously been checked for EMI [electromagnetic interference] pickup, and generally found to be insensitive to the operation of other equipment in the lab and to variations in the power supply; also, such a series of signals had never been seen in the months previous, and a cosmic ray monitor nearby saw no significant change.

The tritium excesses, on the order of 400 dpm/ml, were also noted after 60 days, after the current was increased to > 320 mA/cm^2 and varied; the levels subsequently decreased again. It was noted that since all of the Pd was mixed from the same batch of powder, yet some of the cells did not yield excess tritium levels, spot contamination could not have been responsible. Also, no tritiated compounds have previously been used in the laboratory. The total tritium production during the 1989 and 1990 experiments were calculated as being 2×10^{11} and 1×10^{11} atoms.

In the subsequent discussion, it was indicated that the sintering of the 3 cells which gave tritium was different from that of the other six, but that this difference still needs to be confirmed. It was also noted that some of the (externally) recombined gas was lost, so that actual tritium production could have been higher; hence true branching ratio calculations would not in fact be possible.

ENGLAND & CHINA - METEOROLOGY TRIGGER

N. Hawkins, S. Sh. Yi, X. Zh. Qi, X.D. Li, L. Wang, Q.X. Zu and X. Zhi. Li (Institute of Physics, Beijing, China), "Investigations of Mechanisms and Occurrence of Meteorologically Triggered Cold Fusion At the Chinese Academy of Sciences", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Morrison at CERN ascribes regional variation in fusion cell results to possible sociological factors. In view of the observation of cold-fusion-like effects in electric storms by Shah, Razdan et al. the present paper seeks physical causes of such variation in terms of meteorological conditions.

Previous work on Abrikosov vortices (rotating strings of electron Cooper pairs) and their possible availability in near or actual electric storm conditions is reviewed, together with work on their potential for fusion. A note is attached modeling their possible behavior in fusion cells, predicting short bursts of fusion in standard open cells, longer-term quasi-stable fusion in modified cells and no fusion at all where lack of meteorological availability or the use of closed cells prevents the Abrikosov vortices being available inside the apparatus.

Experiments with modified cells at the Chinese Academy of Sciences, designed to test the meteorological trigger hypothesis and to monitor any resulting fusion, are described. Both continuous and short-burst fusion are reported to occur if, and only if, the hypothetical meteorological trigger-conditions are present. Isotope-ratio and particle-yield analysis may suggest a cathode-surface chain reaction of lithium derivatives, self-terminated by the production of non-fusible ions.

This is taken as being possibly the first observations of meteorological triggers for cold fusion, the first derivation of a surface chain reaction effect and the first reported observation of continuous fusion from this source. Various possible causal mechanisms behind the detailed

results are discussed. A future experimental program to confirm and further define these effects is described.

No claim can yet be made for definite confirmation of the Abrikosov vortex hypothesis, or any other cold fusion trigger or reaction details.

COMMENTS

[In this presentation by Dr. Hawkins, an unusual meteorological phenomena which may be associated with storms was considered a possible catalyst for cold fusion in open electrolytic cells, and to account for irreproducibility of the results of such experiments. Experimental tests were described. Ed.]

Pd electrolysis experiments were conducted on the roof of a building during the storm season in China. Gamma radiation levels measured were found to repeatedly increase during the onset of storms (by 50%, to $5X10^{-4}$ Gray/hour) when the cell was operating properly; the probability of this correlation being due to random chance was calculated to be less than 1%.

(In addition, evidence for possible very brief, high-temperature spikes localized on the cathode surface was inferred from deposition of carbon at the top of the electrode, even though a thermocouple placed at the top of the electrode, with a response time on the order of 10 seconds, recorded rises of only 1 or 2 degrees.)

A tabulation of published results from various locations was presented, in which 5 groups at sites in which electrical storms are common reported successes and 1 reported failures; this was contrasted with 1 positive report and 7 negative reports from other sites. It was noted that an outside location would not be necessary for the proposed mechanism, as it was suggested that the vortices could enter buildings; magnetization of the vortices was suggested to cause them to be attracted to the area of the cathode and remain there for some time.

Previous work suggesting a role for Abrikosov vortices in ball lightning was noted (Dijkhuis, Zeldenhurst College, Holland), as well as possible observations of neutrons and gamma rays associated with lightning and storms.

Experiments involving artificially-created storm conditions are planned.

[The weather hypothesis is intriguing. However, as noted in previous papers, background count rates are known to be affected by meteorological conditions over longer time scales, and some types of equipment are also sensitive to humidity and electromagnetic interference. Thus, further investigation of such a mechanism could best be done if an H_2O control could be run simultaneously. Ed.]

YUGOSLAVIA - Ti GAS LOADING

N. Jevtic, S. Miljanic, S. Pesic, J. Dobrosavljevic and J. Pupezin (Boris Kidric Institute of Nuclear Sciences, Beograd, Yugoslavia), "The Change in the Isotope Ratio and a Spectroscopic Analysis of the Gas from Gas Load Experiments", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Titanium and palladium samples were D_2 gas loaded. Two such systems were cycled from liquid nitrogen to room temperature and in a number of runs to 100 C. Both exhibited an increase in the neutron count only upon the first immersion into the liquid nitrogen. Virgin gas and gas from one of these gas-load cold fusion cells exhibiting an increase in the neutron count at heating of 3 to 4 times background over 1.5 h. were analyzed both mass-spectrometrically and spectroscopically. Mass spectrograms were made on two different systems after the shut-down of the experiments. On both, the change in the relative mass 2 and mass 3 content is evident. Hollow cathode discharge Emission spectroscopy of the gas for T and He prove negative. Though a He4 line was observed in one spectrum, repeated attempts to observe it in the gas from the same sample were unsuccessful.

COMMENTS

[This progress report by Dr. Jevtik describes gas-loading experiments which were largely inconclusive. Ed.]

Forth grams of Ti were used; in the original sample, 5.5 grams of Pd were also present. A BF_3 and an NE213 neutron detector were used (background 0.5 and 108 counts per 15 minutes, respectively).

It was noted that the peaks in the mass spectrometry results could be due to several different species (for example, T and HD); thus it would not be possible to show whether tritium was produced without data at high resolution. Likewise, as previous experiments using He carrier gas had been performed, the ^{4}He line seen could have resulted from a bubble in the grease of the stopcock.

In addition, two Pd electrolysis experiments were performed, using current densities up to 200 mA/cm^2, showing little evidence of neutrons and tritium concentrations consistent with enrichment.

It is hoped that further experiments can be performed in the future, using a better neutron detector with 12 phototubes and 500 liters of scintillator fluid, and a plasma focus apparatus.

OREGON - HEAT ONLY

A.C. Klein, L.L. Zahm, S.E. Binney, J.N. Reyes, Jr., J.F. Higginbotham, A.H. Robinson, M. Daniels, and R.B. Peterson (Oregon State University), "Anomalous Heat Output From Pd Cathodes Without Detectable Nuclear Products", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

In the spring of 1989, an interdisciplinary team of researchers at Oregon State University designed and implemented a laboratory experiment to explore the effects of electrolyzing heavy water (D_2O) using palladium and platinum electrodes. The intent of these experiments was to reproduce as closely as possible the work of Pons and Fleischmann which reported several observations of "excess heat" production, possibly due to deuterium-deuterium fusion reactions. During the past year and one half, over 40 weeks of experimental runs have been conducted in four cells which electrolyze heavy water using palladium and platinum electrodes. Tritium production, neutron and gamma radiation, and cell temperatures were monitored simultaneously and continuously throughout the runs. The OSU experiments have resulted in seven elevated temperature events similar to those claimed by Pons and Fleischmann, with no correlating detection of nuclear products that would be present if the source of the "excess heat" was due to deuterium-deuterium fusion reactions.

Even though several events of increased temperature difference have been observed, no evidence of increased tritium concentrations has ever been observed. Also, significant numbers of neutrons would have been generated if the traditional D-D fusion events had occurred, and average neutron count rates of on the order of 10^{10} cps would have been expected. However, these rates are compared to the observed background of 0.2 to 0.4 cps which has been measured and verified many times during the course of these experiments. Such a great discrepancy shows that no significant amounts of detectable neutrons were emitted from the palladium rod.

The seven events which have occurred to date all take the same general form in which the apparent heat output of a cell, as seen in terms of the measured change in cell fluid temperature, increases in a distinct and significant step. In none of these events was there any intrusion by the experimenter to initiate the change in the cell fluid temperature. In all cases, however, some action by the experimenter caused the termination of the apparent release of heat. In all cases the measured temperature difference returned to the pre-event value. Termination of the events, in many cases, resulted from the addition of D_2O to the cell in order to maintain the fluid level.

Recently, a single light water cell, identical in all respects to those using heavy water, has been operated for over 14 weeks and has produced no temperature excursions, and also no nuclear products.

COMMENTS

[Dr. Klein's presentation described a Pd electrolysis experiment in which excess heat was detected but neutrons, tritium and gamma radiation remained at background levels. Ed.]

The Pd cathodes used (4 mm diam. X 10 cm rods) were obtained from Johnson Matthey; the anodes were Pt. The solution contained 0.1 M LiOD in D_2O. Current densities were 15-300 mA/cm^2. External recombination of gases was performed (using Pt at 425 K).

Temperature measurements were made using 2 thermocouples on the cathode and 2 in the water bath. Neutron measurements were made using 15 BF_3 counters (efficiency 3-5%) surrounded by Cd shielding. (It was noted that some large and sustained neutron pulses were observed, but that these were demonstrated to be spurious.) Tritium monitoring of both recombined D_2O and electrolyte was performed by liquid scintillation. Gamma radiation was measured using a Pb-shielded NaI detector. The detection limit for tritium was $4X10^{-6}$ microCi/ml. Also, an XRF [X-ray fluorescence] depth profile of the cathode was performed after the experiment; this showed the accumulation of Pt, Cu, Si, and a small amount of O in the top few microns.

An example was shown in which a smooth temperature increase of approximately 10 degrees occurred with the same time constant as was seen when the current was increased; this very clear stepwise increase is what would be expected from a sudden development of a steady level of excess power. It was noted that no change occurred in another cell run at the same time on the same power supply, and that levels after each event were the same as levels preceding it. The total excess energy in the events ranged from 8 to 2240 W-hours over 4-364 hour periods; in the largest and longest event the excess power was approximately 7% of the energy input. If this excess energy output were due to d-d fusion, this event would correspond to approximately 10^{19} fusions. No trigger for the events was identified, although events were generally terminated by the addition of D_2O (at 20 C) to the cell (which was at 65 C). During 15 weeks of data for the H_2O control (approximately half the 35 weeks for the D_2O cells), no heat events were seen; in fact, it was noted that the temperature of the control was considerably more stable.

HUNGARY & JAPAN - Fe-Zr ALLOY NEGATIVE

E. Kuzmann, M. Varsanyi, L. Korecz, A. Vertes, F. Deak, A. Kiss, L. Kiss (Eotvos U, Budapest, Hungary) and T. Matsumoto (Tohoku U, Sendai, Japan), "Investigation on the Possibility of Cold Nuclear Fusion in Fe-Zr Amorphous Alloy", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Neutron, gamma and Mossbauer spectroscopy were used to study the possibility of cold nuclear fusion in $Fe_{90}Zr_{10}$ amorphous ribbon having high hydrogen absorbing ability. No significant changes in the neutron and in the gamma spectra were found at deuterization performed electrochemically at different cathodic potentials. The observed differences between the Mossbauer spectra of samples deuterized in air and in nitrogen atmosphere can be explained by a decrease of deuterium uptake as well as by a small heat effect due to reaction of hydrogen with oxygen dissolved in water in the case of electrolysis carried out in air.

COMMENTS

[This presentation by Dr. Kuzmann reported unsuccessful attempts to detect fusion in an electrolysis experiment using an Fe-Zr alloy. Previous experiments at Eotvos U. using Mossbauer spectroscopy to study the hydrogen uptake of such alloys was also described. Ed.]

The alloy selected can absorb up to approximately 1.8 hydrogens per metal atom. A variety of Mossbauer spectra were shown to demonstrate their ability to indicate changes in hydrogen loading and temperature; it was also noted that such spectra could be used to indicate, for example, the proportions of hydrogen in this alloy which resided in the two different sites, and to distinguish between hydrogen and deuterium loading.

The alloy, prepared at Tokohu U. in Japan by spinning the melt in Ar, was 1 mm X 20 microns by 10-20 mm. Electrolysis was performed in D_2O +H_2SO_4 + Na_2SO_4 (pH 2) at currents of up to 15 mA for 5000 seconds. Plastic scintillator and BF_3 detectors were used for fast and slow neutrons, respectively, and a GeLi detector for gamma radiation.

[Possible factors contributing to the negative results in this experiment include the use of an alloy which would form a hydrogen-impeding oxide film in solution, the small sample size and low current density, and the brief electrolysis. On the other hand, the use of Mossbauer spectroscopy to monitor aspects of loading about which other methods give little information was very interesting. It should be noted, however, that its use on a quantitative rather than qualitative basis may be more problematic due to the variety of factors which appear to influence the spectra. Ed.]

CHINA - Pd GAS LOADING

Xingzhong Li, Shiyuan Dong, Keli Wang, Yueying Feng, Lee Chang, Chengmo Luo, Renyong Hu, Pingli Zhou, Dawei Mo, Chongli Song, Yingtang Chen, Minyan Yao, Chuang Ren, Qiankun Chen (Tsinghua U, Beijing, China), "The Precursor of `Cold Fusion' Phenomenon in Deuterium/Solid Systems", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

While a few labs claimed successes in reproducing the "cold fusion" phenomena, the majority of the experiments failed to do so. The criteria for success or failure are supposed to be the "nuclear fusion products", which are difficult to measure in a convincing way. If we could always find some precursors before the "cold fusion phenomena", this correlation between the precursor and the "cold fusion" would make the measurements more convincing. This precursor might also guide us in approaching the "cold fusion phenomena" and make it easier to solve the problem of reproducibility.

The results of experiments will be presented to show the evidence of the precursor in a pressurized deuterium-palladium system. The electromagnetic radiation and the emission of the charged particles are detected. Special methods are used to increase the ratio of signal to noise. The control runs and blank runs exhibited good contrasts between the signals and the natural background. Particularly, experiments indicate that the surface condition is important for the reproducibility. The results have been compared with a similar one in another lab.

This precursor is qualitatively consistent with the theory of shielded coulomb barriers and the existing nuclear reaction data at low energy.

This work is supported by the Natural Science Foundation of China and the contingent funds from the National Education Commission.

COMMENTS

[The presentation by Dr. Li described a gas-loading experiment using Pd rather than Ti, in which the total charged particle production during the experiment was recorded using a track detector. Ed.]

This experiment was reported at the May 10-12, 1990 cold fusion symposium in Beijing, China. Samples were exposed to D_2 gas at 9 atm, then cooled in liquid nitrogen. The cumulative charged particle emission from the surface was measured using thermoluminescence (CaF_2) and plastic track (CR-37) detectors.

Track densities were much higher for the D_2-loaded Pd sample than for the H_2-loaded Pd sample or the D_2 gas samples (which in turn were 2-3 times the background density). Tracks were in some cases highly localized in particular areas. When half of the D_2-loaded Pd was covered by 0.2 mm of Al, the track density on the covered half was shown to be much lower than on the uncovered half.

The lack of a similar effect was noted when Pd cleaned with aqua regia was used; it was suggested that this was due to chlorine remaining at the surface after cleaning, as indicated by Auger spectroscopy.

In addition, measurements were made in an attempt to detect "precursor" electromagnetic radiation expected in the UV to soft X ray region.

SPAIN - LOW-LEVEL TRITIUM

F. Fernandez, J. Sevilla, B. Escarpizo, C. Sanchez (Dpt. Fisica Aplicada, Universidad Autonoma de Madrid, Spain), "Nuclear Effects In Electrolytically Deuterated Ti and Pd", Proceedings of Anomalous Nuclear Effects In Deuterium/Solid Systems, Brigham Young University, October 22-24, 1990.

ABSTRACT

Since April 1989 we have performed electrolytic experiments in order to reproduce and control cold fusion events. In this communication we will present a summary of our experiments, regardless of whether the results were positive or not (Solid State Comm. 21(12) p 1039, 1989).

The detection system available covered the measurements of the total number of neutrons (BF_3 detectors), neutron energy (proton recoil spectrometer), gamma-ray energy (NaI and Ge spectrometers) and tritium electrolyte content (scintillation counting after sampling). In most cases all detectors were used in the same experiment looking especially for coincidences in anomalous detection.

Typical data on the behavior of the different parameters are presented. Positive results are discussed and parallelism between negative results and blanks is also shown. Misleading results will be included as well as a discussion about the error sources we have found in this kind of measurements.

We consider that the knowledge of the final state of the cathode has to be as accurate as possible in order to understand the physical-chemical processes underlaying cold fusion. With this purpose, in some cases, we have followed a four step measurement routine at the end of the experiment including X-ray diffraction, Electron Microscopy and Surface Analysis (EDAX), Thermal Desorption and Differential Scanning Calorimetry. On the basis of the experimental results a brief discussion on D-loading and the after-experiment surface morphology is presented.

At the present moment we keep on running experiments oriented to detect nuclear reaction products, and we investigate some physical problems that according to some theoretical proposals could be steady state breaking agents, like, for example, the main features of the fcc-fct phase transition suffered by TiH_x when $x > 1.6$.

COMMENTS

[The presentation by Dr. Sevilla reported the generation of low levels of tritium during electrolysis experiments. Ed.]

Tritium levels of 100 dpm were measured in one cell (approximately 8 times initial values), and lower amounts in a second cell. No control was run, although a parallel experiment gave no increase. In the cell with high production, tritium slowly declined again afterwards. It was noted in subsequent discussion that only the electrolyte had been assayed, and not the gas.

In addition, the neutron count rate data in another experiment showed deviations of a few standard deviations above the Poisson distribution at the highest count rates. However, these represent count rates of only 11-14 counts per 5-hour interval; no accompanying increase in tritium was detected.

Analysis of the cathode surface after several days of electrolysis showed increases in Si from the glass, Pt from the anode, and S from the electrolyte, and cracks and other alterations in the surface.

USSR - ACOUSTIC SIGNALS

Vladimir Tsarev (Lebedev Physical Institute, Moscow, USSR), "Experimental results on neutrons, protons, and theoretical model, geophysical."

COMMENTS

[This model involves fractofusion (acceleration of deuterons in electrical fields across cracks), and possible experimental evidence is noted. Ed.]

It is noted that electrons, ions and electromagnetic radiation have been reported during fracture of dielectric crystals, and that neutron emission apparently correlated with acoustic emission has been reported in certain experiments (such as those of Golubnichyi). However, the manner in which this mechanism would be able to operate in metals during changes in the hydride phase, and the apparent lack of emission of electrons, needs to be explained; very high loading or a metal-insulator transition due to lattice dilatation (Mott effect) may play a role.

If this mechanism is correct, correlation of fusion products with acoustic and radio emission should also occur in deuterated Pd and Ti, and it is suggested that various types of shocks (including mechanical, thermal and current level changes) could act as triggers.

In an electrolysis experiment involving Pd in D_2O + 0.1 M $LiClO_4$, with current densities up to 200 mA/cm^2, 6 bursts of 100 neutrons each (greater than 10 times background) were in fact detected after cryo- and thermal shocks, using a coincidence between signals from a plastic scintillator (for fast neutrons) and 10 ^3He tubes with oil moderator (for slow neutrons). Controls were run at zero current and using H_2O. Efficiency was 3%, and background was $5X10^{-3}$/second.

In another run, two events were seen during 11-1/2 hours in which neutrons, acoustic signals and radio emission were correlated in a 10 msec window; the inferred fusion rate was stated to be 10^{-2}/sec/gram, comparable to the Jones level. The probability of such a triple correlation having occurred by random chance during this time period was calculated to be 10^{-7}. A control with H_2O was negative. However, the number of events was too small, so another run was performed in an underground site (Baksan). Six double coincidences of slow neutrons and acoustic signals were seen in 4 hours, for an average of $3X10^{-2}$ n/sec. Further experiments are planned.

Tritium was also found, but only on the first desorption; this needs to be confirmed.

WORLEDGE - SUMMARY

D. Worledge (EPRI), "Summary of Progress"

COMMENTS

[Dr. Worledge noted that in his opinion the conference had been a successful one, with a much larger number of contributors than originally expected, and a lot of data, too much for him to tabulate, as he had originally planned. He noted that his presentation was intended as a summary of progress in the field, putting the material presented at the conference in the larger perspective. Ed.]

Among the general features which he perceived had changed little since a year ago were the usual types of experiments (predominantly Pd electrolysis and Ti gas-loading, although a few additional types including Pd gas-loading and ion implantation were now being reported). Also, the field was clearly still an active one, with both positive and negative results continuing to be reported but possibly fewer negative reports. (In fact, the field seemed surprisingly active given the low funding level.) The experiments reported were noted to still vary vastly in quality; it was suggested that the increasing amount of effort that went into some of them was acting as a confidence-builder for skeptics, but that this was a serious concern on which it would still be necessary to work harder. Tritium was noted to still be the least reproducible, in his opinion, although reports of small amounts were fairly common. Additional high-quality neutron measurements confirming the Jones results were noted, along with some higher rates which Dr. Worledge indicated he didn't know how to view. Repeatability of high-multiplicity neutron bursts was considered to remain low, with questions as to timing and triggering. Finally, it was noted that observations of X-rays, gamma rays, and He remain few.

Among the areas perceived to have changed since January 1990, on the other hand, are improved reproducibility of low-multiplicity neutron spikes and random neutrons. In a few cases, reproducibility approaching 100% was indicated. Also, neutron observations which have survived changes in detectors, environments, and research groups were noted. New charged particle observations besides Dr. Taniguchi's were mentioned, with tentative identification of some of the particles as tritons. Dr. Worledge indicated that he felt that metallurgical variations and batch-to-batch variations were now being taken more seriously as important factors, even though it is not yet clear how best to control them. Likewise, it was felt that the behavior of deuterium and tritium in Pd has become better known, and there is a better appreciation of the complexities which can be involved. Finally, better evidence that there can be tritium contamination was noted.

Among ways to improve confidence in the results being reported were confirmation by other groups, improved reproducibility, and reports of many occurrences (rather than merely more reports of a few occurrences). It was suggested that success rates of over 50% would both make it easier to get funding and allow the necessary tests to determine appropriate experimental parameters. Other needs listed were concurrent measurements of backgrounds, adequate numbers of blanks and hydrogen controls, use of more than one detector of the same type and detectors of different types (especially convincing if two detectors work on different principles, and if different detectors respond simultaneously, as shown for example by BARC), improved signal-to-noise ratio (especially if the size of the signal stays the same, as in some recent experiments), and demonstration that the results are not affected by changes in the lab environment (such as electrical noise or humidity). It was noted that at least most of these features have to be incorporated into an experiment to give confidence in the data. Finally, the need for proper attention to random and systematic errors, and the need for appropriate expertise, were noted. (For example, in experiments at the cutting edge of neutron measurements, it would be hard to convince others unless a neutron physicist were involved.)

It was noted that EPRI's assessment has been that the way to show the existence of cold fusion or write it off would be with nuclear measurements. The need for improved quality and reproducibility in nuclear experiments (including the search for tritium contamination, control experiments for tritium run in the same electrolyte, lower background rates, ^{4}He assays, geologic evidence, and delta-E/E particle identification) was stressed again.

The need for study of the excess heat and associated physical circumstances, on the other hand, should not be neglected. Collaboration and integration of experiments and results was once again strongly urged.

Various recurring or provocative puzzles in Pd electrolysis experiments were mentioned: How can the low levels of tritium contamination reported exit the cathode sometimes but not in others (as Dr. Wolf suggests may be possible)? In addition to the contamination reported by Dr. Wolf in 3 cells, are larger amounts possible too? In Dr. Storms' results, tritium deliberately introduced into the Pd came out easily and in the gas, while experiments reporting tritium production find it predominantly in the electrolyte; what implication does this have? Some reports have tritium produced early in the electrolysis, and others only after a delay; this difference may be important, but why does it occur? Low levels of random neutrons tend to be observed early, even before the cell is fully charged, or correlated with changes in current density; neutron spikes, on the other hand, don't correlate in a clear way with particular parameters- what does this mean?

Regarding the electrolysis experiments, it was noted that random neutron energies of about 2.5 MeV (which have in most cases been reported in Pd), and possibly also higher-energy neutrons, are interesting, as are the continuing reports of neutron/tritium ratios of $10^{-8+/-1}$, and the large neutron bursts in some experiments. It was noted that information from underground sites is now helping to establish that the low-level random neutrons are not from cosmic rays.

Regarding the gas-loaded Ti experiments, correlation of neutron spikes with temperature transients, and the absence of correlations of such spikes with cosmic rays, were noted. However, the scarcity of determinations of the energies of the neutrons in the spikes was pointed out, as was the scarcity of data on whether random neutrons are also produced.

Regarding charged particle experiments, the point was made that the general lack of secondary reactions suggests that charged particles such as tritons produced during the Pd electrolysis experiments typically have energies on the order of 15 KeV or less, while other experiments have measured some such particles with energies up to approximately 5 MeV. This was suggested as providing a major constraint on theoretical explanations.

Other points made included the frequent suggestion that high deuterium loading and/or disequilibrium conditions (which could produce high local loading) may be needed. Also, the interesting observation was noted in early data presented by Dr. Wolf, in which some cathodes gave random neutrons while others did not, and when all of the cathodes were reannealed (3 times in all), it was the same ones which continued to give neutrons. Similarly, data suggesting that neutron spikes were reproducibly lower for some Ti batches than others was noted. The suggestion that cold working may increase neutron spike reproducibility was also mentioned, and it was pointed out that increasing sample volumes typically did not increase output by an equivalent amount.

Steps identified by Dr. Worledge as being needed were better tritium/Pd models (including porosity/crack formation), better (sample and control) tritium data plus diverse neutron detectors (preferably concurrent) and delta-E/E particle identification in Ti/gas experiments, lower background in random neutron measurements in electrolysis experiments, delta-E/E particle identification in electrolysis experiments with thin Pd cathode walls, and ^{4}He assays on Pd and Ti.

In conclusion, although many experiments were judged to have greatly improved in quality (including some extremely good scientific work), and many rather different experiments were giving a similar pattern of results -- which favored a process different from normal D-D fusion -- it was suggested that the experimental evidence to date still gives too little guidance to theoreticians, and more definitive information is needed. It was indicated to funding agencies that this was a legitimate field that needs support.

BRIEF REMARKS

ITALY - SCARAMUZZI

Dr. Franco Scaramuzzi of ENEA, Italy noted that much high-quality instrumentation has been reported to be coming into a number of laboratories, and that results should follow, which he expects to lead to more concrete answers in the next year. Therefore, he proposes another workshop with the same title, to be held in Varenna, Italy (sponsored by the Italian Physics Society), around September or October 1991.

Since the number of papers submitted to the conference just concluded was too great for a 3-day conference, leaving no time for some of the papers to be presented and far too little time for discussion, a length of 4 days was suggested in which to present the same number of papers as were submitted to this conference. A referee process for papers to be published in the proceedings was also proposed.

Dr. Scaramuzzi also recounted a curious and suggestive story which could represent the production of cold fusion during an experiment in 1951-2. At the time, Dr. Germagnoli was making delicate neutron cross-section experiments at the Italian CISE physics lab, and a few meters away Drs. Marchetti, Cerrai and Silvestri were performing a deuterium enrichment study in which impurities were filtered out by passing the deuterium through a Pd-Ag tube. On a number of occasions, Dr. Germagnoli accused his colleagues of using a neutron source in their lab and spoiling his measurements.

INDIA - SRINIVASAN

Dr. M. Srinivasan of BARC, India proposed the establishment of an international data bank on theory and experimental results in cold fusion, eventually accessible via a network. (Similar data banks are used in other fields.) Dr. Jones offered BYU as one node, and it was suggested that additional nodes be formed in other countries to collect and pass on information originating in those areas. A standard format would need to be developed (including names, phone and fax numbers, abstracts, and results presented in a standardized fashion).

[Fusion Facts also urges standardization of experimental data. All too frequently, vital information cannot be determined from published data. For example, in reporting neutron emission rates, an article may not note whether this reflects the count rate or the calculated production rate. Likewise, background count rates and statistics, detector efficiencies, cell voltages and current densities, electrolyte compositions, electrode treatment, or similar potentially relevant information may be omitted. Ed.]

ILLINOIS - MILEY

Dr. George Miley (U of Illinois) indicated that experiments using a plasma focus device with an axial magnetic field to lengthen the plasma lifetime and thus allow more time for implantation are beginning in an attempt to replicate the BARC, India results reported by Dr. Srinivasan. (Only 1 sample has been run to date.)

MORRISON - NO PATHOLOGY?

Dr. Douglas Morrison of CERN made a variety of what were described as general preliminary comments. He expressed the view that the conference represented a big improvement over previous ones, although he pointed out that the time available for discussion and comments was still not sufficient. The frequent technical improvement in the quality of the experiments was noted (lower backgrounds in underground labs, systematic efforts by researchers to check for errors, as much hydrogen control data as sample data, more careful statistical and other analysis, etc.). To minimize spurious counts, it was also suggested that detectors should be completely surrounded with a veto counter.

However, the question of careful yet unsuccessful experiments was brought up. Doubts were raised as to whether null results could necessarily be attributed to insufficient loading or times, based on information in some of the presentations- for example, it was pointed out that in the Menlove and Jones experiments, D/Ti ratios of only approximately 0.3 were used. Also, it was suggested that positive tritium reports seemed more common in labs in which other sources of tritium were present. Finally, Dr. Morrison made the [excellent] point that the fraction of groups reporting count rates only several standard deviations above background was statistically unreasonable (given that the background levels in the experiments varies widely) unless a number of these reports are actually negative.

Dr. Morrison indicated that in his estimate over 90% of the world's scientists still judge that cold fusion does not exist; the probability of excess heat was judged to be extremely low, and the probability of fusion products small. One reason mentioned was the existence of careful experiments which find no effects; convincing experiments and improved reproducibility would be necessary to change this situation. Finally, it was strongly suggested that the length of time which had now elapsed is such that it is now too late for poor experiments to be justifiable.

CHINA - INITIAL EVIDENCE

Dr. Zhongliang Zhang of the Institute of Chemistry, Academia Sinica, People's Republic of China, reported the observation of a 1-hour elevation in the power output in an electrolysis experiment. Charged particle measurements were also attempted. The total current was only 2 mA. The electrolyte contained 0.1 M LiOD. A control with H_2O was also run.

ROMANIA - METALLURGICAL

Dr. George Dragan of Romania raised the need for additional attention to metallurgical aspects, and noted that the solubility and kinetics for hydrogen uptake are very sensitive to such factors.

MISSOURI - EXPERIMENTAL CARE

Dr. Peter Handel of the U. of Missouri stressed the need for establishing better correlations between experimental conditions and output. For example, data from experiments by Drs. Klein and Montgomery was noted which suggested that small, temporary increases in the voltage at constant current, or decreases in the current at constant voltage, followed by sudden decreases in the amount of D in the electrode, may have preceded neutron pulses.

UTAH - DETECTORS

Dr. Steven Jones of Brigham Young U. made the suggestion that experimenters attempt to make use of a major detector, rather than relying solely on a detector of their own. For example, it was noted that Dr. Jones has accepted the offer to use the Kamioka detector described by Dr. Totsuka, which is possibly the most sensitive neutron detector in the world, and has asked to have a period of a few weeks in order to have a reasonable chance of seeing an effect. (Dr. Jones also mentioned examples of previous efforts to take advantage of other groups' facilities, such as counting of cells from Drs. Menlove and Wolf in a Colorado School of Mines underground site.)

Dr. Jones also critiqued an example of an electrolysis experiment performed by another group using Jones-type cells (D. Aberdam et al, Physics Rev Lett 65 #10), with negative results. It was pointed out that the length of the experiment, 45 hours, might not have been sufficient to see what has been indicated to be a potentially infrequent effect. In addition, it was noted that the use of Ti turnings in an electrolysis environment typically results in very low loadings; Dr. Jones' original experiments (as well as experiments at Gran Sasso and LANL) used a large amount of fused material (consisting of very many tiny crystals in order to give a very large surface area, to help the deuterium penetrate the material despite the surface oxide layer), yet even under these conditions the loading measured was only 0.5%. A second technique used by Dr. Jones to aid in loading was a Pd coating on the Ti.

H. CALL FOR PAPERS ETC.

CALL FOR PAPERS

Courtesy of Subbiah Arunachalam

The Indian Journal of Technology (the third journal -- after *J. Electroanal. Chem,* and *Nature* -- to publish an original research paper on cold fusion) invites papers. Both original research papers and critical review articles in all areas of cold fusion are solicited.

Manuscripts may be sent, in duplicate, to Editor, Indian Journal of Technology, PID, Hillside Road, New Delhi 7110012, India.

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Technical Notes do not have a page limit but they typically run 2-4 journal pages (1 journal page approx. = 3 double-spaced typed pages). A brief abstract is required. ASCII format computer media can be accepted.

Technical Notes will be reviewed but the process stresses rapid response. **Reviewers are instructed to consider Technical Notes as speculative, sometimes incomplete work that should be judged on the basis of innovation, originality, and importance to fusion power development. Appropriate citations to prior work are also essential.**

Deadlines for future issues are as follows:
July 1991 issue: December 21, 1990

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