Abstract Submitted
for the May 1989 Meeting of the
American Physical Society

RFC'D.
MAR 30 1989
A.P.S.

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Date

Sorting Category

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Limits on Cold Fusion in Matter: a Parametric Study.*

J. RAFELSKI, M. GAJDA, D. HARLEY and S.E. JONES**, University of Arizona

—The rate of nuclear fusion of d-d hydrogen isotopes is studied as a function of several parameters, and is found to be critically sensitive in a regime of the parameter space that could be of physical relevance and also account for the fusion rate recently measured by Jones *et al*. The fusion rate in the $(dde)^+$ ion-like structure is computed as a function of the maximum allowed hydrogen separation and as a function of an effective electronic mass and charge, leading to a fusion rate of the needed magnitude. These numerical exercises highlight the extraordinary sensitivity of the fusion rate to the physical parameters and the environment characterizing the system in which the $(dde)^+$ complex is embedded. It is further shown that the effect each of these parameters has on the fusion rate is cumulative and that a neutron rate of $10^{-23}\,s^{-1}$ per atom is obtained with a plausible combination of these parameters. The fusion rate resulting from a low energy, less than 100 eV d-d scattering description is also computed and is shown to be too small.

* Work supported by DOE/AEP

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M. DANOS, NIST
Suggested Chairperson

Abstract submitted
for the special session on cold fusion
at May 1989 General Meeting of APS in Baltimore
April 21, 1989

Fusion Rates for Hydrogen Isotopic Molecules of Relevance for Cold Fusion* K. SZALEWICZ, J.D. MORGAN III: U. Delaware; H.J. MONKHORST: U. Florida. — In response to the recent announcements of evidence for room-temperature fusion in the electrolysis of D_2O, we have analyzed how the fusion rate depends on several factors, including the reduced mass of the fusing nuclei and the degree of vibrational excitation. Calculations have been performed within the adiabatic approximation employing an accurate Born-Oppenheimer potential energy curve and including the adiabatic and relativistic corrections. We have also used the WKB approximation which displays the essence of these factors. Our results predict fusion rates for the ground vibrational states up to 14 orders of magnitude larger than previously estimated and exhibit a strong dependence of the Coulomb barrier penetration factor on the reduced mass of the pair of nucleons. We have found that fusion out of vibrationally excited states is enhanced by several orders of magnitude, which may be of particular significance in light of the experimental evidence for the importance of non-equilibrium conditions. To assist in the investigation of whether a 'heavy' electron arising from complicated collective solid-state effects could play a role in the enhanced fusion rates seen in the experiments, we study how the Coulomb barrier penetration factor depends on the mass of a hypothetical particle (or quasi-particle) of charge -1. We examine the issue of whether the excess heat observed in one of the experiments could arise from the aneutronic fusion reaction $p+d \rightarrow {}^3He+\gamma$. We find that under the conditions implied by the measurements of the neutron flux from the reaction $d+d \rightarrow {}^3He+n$, it is unlikely that the excess heat observed by one of the groups could arise from $p+d$ fusion.

*Supported by the NSF and by the Division of Advanced Energy Projects, DOE.

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Abstract Submitted

for the Spring Meeting of the

American Physical Society

May 1, 1989

Cold Fusion

Cold Fusion Special Session

Theory of Cold Fusion. M. Danos, NIST. --The lowest order Feynman graph leading to dd fusion in the vicinity of a lattice nucleus, M, is given by the tree graph Fig. 1. We assume that the deuteron d_1 is trapped (trapping wave function $\psi_0(t)$) and the deuteron d_2 flies by with relative velocity $v^2 = (2T/m)$ ($\hbar = c = 1$). All momenta $t_i \lesssim 50$ meV are

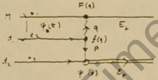

Fig. 1

thermal. Hence the initial state is given by a density matrix. In the final state $E_f + \epsilon_f = Q = 24$ MeV. The electromagnetic vertices $F(q)$ and $f(q)$, even though off-the-mass-shell, are given in order of magnitude by the form factors known from electron scattering, and $\psi(p)$ is the momentum space wave function of the d-d component of the ^4He ground state, which can be estimated from nuclear structure data. The order of magnitude of the resulting rates corresponds to the observed rate of 10^{-19} sec^{-1}. (The reaction mechanism is easiest understood by considering the time-reversed reaction.) The suppression of the emission of protons or

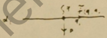

Fig. 2

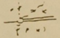

Fig. 3

neutrons arises from the replacement of $f(q)$ by the break-up from factor $\tilde{f}(q, q_1)$, Fig. 2, and by the replacement of the 2-body by the 3-body density of states. Similarly, the photon emission is suppressed by the replacement of the fusion vertex $\psi(p)$ by $\tilde{\psi}(p, k)$, Fig. 3. The details will be presented.

Submitted by [signature]

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RFC'D.
APR 18 1989
A.P.S.

Abstract Submitted
for the 1989 Spring Meeting of the
American Physical Society
April 14, 1989

Sorting Category 22

Electron Catalyzed Fusion in Metals*. D. A. BROWNE, R. G. GOODRICH, P. N. KIRK and E. F. ZGANJAR, L.S.U. — We present a simple model for the induction of nuclear fusion in metals through the formation of neutral and charged deuterium complexes similar to the mechanism of muon catalyzed fusion. The role of various materials properties of Pd and other metals in enhancing the fusion rate will also be discussed. We are currently taking measurements on a sample of Pd and a heavy fermion material and will present the results of our experiment in light of the model.

*Supported by LSU Center for Energy Studies

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Prefer Standard Session

S. E. Jones
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EXPRESS MAIL

APR 26 1989

A.P.S.

Abstract,
Baltimore Spring Meeting,
American Physical Society
May 1-4, 1989

Cold Fusion, May 1, 1989

Sources of Neutrons and Tritium from D-Li-6 Mixtures. Lawrence Cranberg, TDN, Inc. --The work of Fleischmann, Pons, and Hawkins (1) claims detection of room temperature fusion of deuterons based in part on detection of neutrons and of tritium in electrochemical experiments with vessels containing mixtures of compounds of deuterium and lithium-6. Alternative, well-known nuclear reactions induced by ambient gamma-rays and neutrons in the experimental materials are suggested, together with suitable control experiments to measure those effects. It is significant to note that a negative result on (1) or on the work of Jones et al. (2), with experimental cells replaced by a blank or hydrogen-filled cell is not a check on the proposed background sources.

1. M. Fleischmann, B. Pons, M. Hawkins, J. Electroanalytical Chemistry, 261, 301 (1989).
2. S. E. Jones, E. P. Palmer, J. B. Czirr, D. L. Decker, G. L. Jensen, J. M. Thorne, S. F. Taylor, and J. Rafelski, Preprint of article submitted to Nature.

Submitted by Lawrence Cranberg, Ph. D.,
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April 23, 1989

Abstract Submitted

for the Baltimore Meeting of the

American Physical Society

1-4 May 1989

Special Session:
Cold Fusion

Search for Fusion Products Using X-Ray Detection. M. R. DEAKIN, J. D. FOX, K. W. KEMPER, E. G. MYERS, W. N. SHELTON, and J. G. SKOFRONICK, Florida State University.* -- The fusion of deuterons should produce energetic protons in about half the reactions in an electrolysis cell with Pt anode and Pd cathode. Our cell is specially constructed with a thin window so that K x-rays of Pd, excited by charged fusion products (mostly protons) can be detected. The background of the x-ray detector, 3 counts per hour in the vicinity of the Pd K x-rays, corresponds to fewer than 50 fusions per second or a fusion energy release rate of less than 10^{-10} watts in the Pd cathode. The cell has been operated for two weeks as of 4/29/89.

*Supported by the National Science Foundation and the State of Florida.

Submitted by:
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Search for Cold Fusion in Electrolytic Cells, D.R. McCRACKEN, J. PAQUETTE, R.E. JOHNSON, N.A. BRIDEN, W.G. CROSS, A. ARNEJA, D.C. TENNANT, M.A. LONE AND W.J.L. BUYERS, Chalk River Nuclear Laboratories. - A variety of electrolytic cells have been studied having palladium cathodes in the form of wires, tubes, rods or foil and having anodes of platinum wire or foil, or of nickel tube. Some of these cells have a cylindrical configuration similar to the cell in which cold fusion is claimed by Fleischmann and Pons to have occurred. The electrolyte was 0.1 molar LiOD in virgin D_2O. An AECL wet proofed catalyst above the cell was used to recombine the evolved D_2 and O_2. Current densities up to 140 mA/cm^2 have been applied. Arrays of 3 to 5 ^{3}He detectors were mounted beside each cell in a central 20 cm cavity of a large 130 cm × 120 cm × 90 cm wax neutron shield. This gives a very low, constant background of 30 ± 2 counts/hour summed over all five detectors or 18 ± 2 counts/hour for three detectors. After running the cells for times of three to four days no excess neutrons were observed above background. The cells were run mainly in continuous mode but a search for transient neutrons was also done after switching on the current. No measurable excess heat was observed in the water from the cooling jacket. In a cell without a recombiner the enrichment in tritium in the electrolyte was not inconsistent with the range of D/T separation factors that occur at palladium electrodes.

The Cold Fusion Rate of d-d in PdDx Hydride and the Branching Ratio of He-4 to (p,n) Production Reactions. Hiroshi TAKAHASHI Brookhaven National Laboratory

Many electrons from the d and s conduction bands of PdDx hydride pile up near deutrons. This accumulation reults to large screening of potential between deutrons and enhances the cold fusion rate. The number of the piled up electron is approximately proportional to the inverse of the density of the conduction electron level at the Fermi level; the linear response theory underestimates the number of electrons by about a factor of 4 less than the non-linear response theory.

The branching ratio of the production process of He-4 to (p and n) is extremely small in the collision experiment, and the transition from the s wave channel in cold fusion to the ground He-4 0+ state by emitting gamma -ray is prohibitive. The He-4 production process of emitting the surrounding electrons becomes appreciable, and to get an extremely large branching ratio requires the coherent direct excitation of optical phonons of PdDx hydride or coherent excitation through the surrounding conduction electrons by a the strong electron lattice coupling.-- This work is supported by DOE Advanced Energy Project Division.

Abstract Submitted
for the May 1989 Meeting of the
Division of Nuclear Physics
American Physical Society
May 1-4, 1989

PACS No.
25.70.Jj

Suggested Session
Fusion

Upper Limits to Fusion Rates of Isotopic Hydrogen Molecules at High Electron Density Interstitial Pd Sites.* L. WILETS, M. ALBERG, J.J. REHR and J. MUSTRE de LEON, **Univ. of Washington.**—We have studied upper bounds for p-d and d-d fusion rates in a degenerate electron gas as a function of screening electron density ($\propto r_s^{-3}$) and confinement potential in a Pd lattice. At tetrahedral (T) and octahedral (O) sites of saturated PdD we estimate r_s to be between 2.0 and 2.8 a_0, which gives an upper limit of $10^{-57}/s$ for p-d and $10^{-67}/s$ for d-d. A rate $10^{-20}/s$ would require an r_s of 0.27 a_0 for p-d. Confinement by the Pd atoms considerably enhances these rates. With a T-site hard cell radius of 0.65 a_0 we obtain upper bounds of $10^{-30}/s$ and $10^{-34}/s$ respectively; rates at O-sites are lower. However, a more realistic confinement potential at the T-sites is softer and gives only $10^{-49}/s$; moreover, occupation of T-sites is chemically (and perhaps structurally) unfavorable, given a D_2 confinement energy of about 30 eV. We conclude that fusion in Pd is most favorable at the T-site, but even there at rates significantly less than quoted experimental values of $10^{-19} - 10^{-23}/s$.

* Supported in part by the DOE and the NSF.

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Calorimetry, Neutron Flux, Gamma Flux, and Tritium Yield from Electrochemically Charged Palladium in D_2O

Nathan Lewis, Charles Barnes, and Steve Koonin

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We report the results of our work on cold fusion using palladium. We have used extremely sensitive neutron, gamma ray, and photon counters, and can place strict upper limits on the flux of expected nuclear products emitted from charged Pd cathodes. Liquid scintillation counting has been used to measure tritium production, which was found at background levels for extended periods of time. However, a subtle chemical interference that generates chemiluminescence has been shown to yield trituim signals and lead to overestimates of the fusion yield based on tritium production. We have also performed accurate, calibrated calorimetry, and have identified several serious errors that can make the measurements appear to show excess power production. When these common errors are eliminated, a correct energy balance is obtained. We will also discuss the calorimetric experiments performed by the Utah researchers, will explain their calculations to the physics community, and will clearly state the assumptions and corrections implicit in the Utah calculations.

RFC'D.
APR 2 6 1989
A.P.S.

Abstract Submitted
for the Spring Meeting of the
American Physical Society
Baltimore, Maryland
May 1-4, 1989

A Search for Cold Fusion Neutrons at ORELA. D.P. HUTCHINSON, R.K. RICHARDS, C.A. BENNETT, C.C. HAVENER, C.H. MA, F.G. PEREY, R.R. SPENCER, J.K. DICKENS, B.D. ROONEY, ORNL,* J. BULLOCK IV, and G.L. POWELL, Y-12 Development--A number of experiments were begun on 29 March 1989 to look for neutron emission from a palladium cathode in an electrolytic cell using a deutrated electrolyte. Several different electrode configurations were tried. The fast neutron detector utilized a pair of NE213 scintillator/photomultiplier pairs in a shielded enclosure. Data will be presented on the efficiency and background level of the detector system. At present no neutron counts above the background level have been detected.

*Operated by Martin Marietta Energy Systems, Inc. for the U.S. Department of Energy under contract No. DE-AC05-84OR21400.

Submitted by
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Signature of APS Member

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COLD FUSION: CAN IT BE TRUE? A THEORETICAL POINT OF VIEW

J. RAFELSKI, University of Arizona, Tucson

It is shown that the fusion rates observed by the BYU team of S.E. Jones during electrolytic infusion of hydrogen into Pd and Ti cathodes can readily be explained by combination of standard nuclear physics data and WKB penetration integrals in the metal lattice environment. A specific mechanism for the process invoking formation of Bose macroscopic state (drop) of deuterium ions neutralised by an electron cloud will be described.
State of the attempts to skew the branching ratios of nuclear reactions by 12 orders of magnitude towards processes not involving production of neutrals (neutrons, gammas) will be given. This would be needed to account for production of heat without penetrating radiation in a nuclear process, as suggested by the press release of the University of Utah.

REC'D.
APR 21 1989
A.P.S.

Abstract Submitted

to the Special Session on Cold Fusion

for the Meeting of the

American Physical Society

Baltimore, Md.

May 1, 1989

Electrochemically Induced Excess Heat in a "Cold Fusion" cell with a Zr_2Pd Electrode Joseph Cantrell, Dept of Chemistry and William E. Wells, Dept. of Physics, Miami university, Oxford, Ohio—A "Cold Fusion" cell patterned after that of Fleischmann and Pons[1] was constructed using Zr_2Pd foils instead of Pd rods. The total volume of the electrode was 0.014 cm^3. At a room temperature of 289 K, the electrodes drew 90 mA with 4.8 V applied, and presented a 6 K change in temperature. When a 10 ohm resister, drawing 219 mA in the heavy water bath, was used to produce heating instead of the electrodes, the temperature rise over the 289 K background was 3 K. The process has continued for more than 100 hours. No neutron measurements have been made as yet. The temperature dependence of the process is being examined and will be reported.

1. Fleischmann and Pons J. Electroanal. Chem., 261 301-308 (1989)

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RECD. APR 25 1989 A.P.S.

Abstract Submitted
for the Special Cold Nuclear Fusion Session
of the 1989 May Meeting of the
American Physical Society
May 1, 1989

Gammas from Cold Fusion. D. Bailey* University of Toronto: **. – The absence of both neutrons and gamma rays can be used to constrain possible cold fusion processes in deuterium-metal systems. In particular, milliwatt cold fusion processes in palladium producing fast protons, tritium, ^3He or ^4He nuclei would also usually produce easily observable numbers of Coulomb excitation palladium gamma rays. Typical expected yields are $\sim 10^4 - 10^6$ gammas per joule of fusion energy in lines at 0.374, 0.434, 0.512 and 0.556 MeV. Reported[1] 2.2 MeV *np* capture gamma rays are consistent with the ubiquitous radon daughter ^{214}Bi 2.204 MeV background line.

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** Supported in part by NSERC (Canada).

[1] M.Fleischmann, S. Pons, and M. Hawkins, J. Electroanal. Chem. 261 (1989) 301, and *errata*.

Special Cold Fusion Session ______________

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RFC'D.
APR 27 1989
A.P.S.

Abstract Submitted
for the May 1st 1989 Meeting of the
American Physical Society

26 April 1989

Special Session on Cold Fusion
Sorting Category

Criterion for Cold Fusion in the Condensed State
E.A. STERN* *Physics Dept. FM-15, University of Washington, Seattle, WA 98195* -- To increase the rate of tunneling through the coulomb barrier between two nuclei of isotopic hydrogen in the condensed state, the surrounding electrons must provide a more efficient shielding than occurs in the molecule. Koonin and Nauenberg(1) expressed this increased shielding requirement in terms of at least a five-fold increase in the electron mass to be consistent with claims of experiments. From Thomas-Fermi screening theory this requirement translates to at least a $5^3 = 125$-fold increase in the electron density from its value in the molecule. This required density is several orders of magnitude greater than occurs in metallic hydrides in either the interstitial sites or any defect sites where hydrogen can reside. Cold fusion cannot occur in the condensed state under conditions employed in the reported experiments.

*Research supported by DOE grant DE-FG06-84ER45163.

(1) S.E. Koonin and M. Nauenberg, Santa Barbara Institute for Theoretical Physics preprint NSF-ITP-89-48, April 1989.

Ed Stern

Signature of APS Member

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PACS 28.50.Re,
52.55.Pi,
82.65-i,

Abstract Submitted for the 1989 Spring Meeting of the American Physical Society 1-4 May, 1989

Suggested title of session in which paper should be placed
Cold Fusion

Search for Neutron Production in a Palladium-Heavy Water Electrolytic Cell* R. HIROSKY, E. BUCHANAN, J. JORNE, A.C. MELISSINOS, and J. TOKE, University of Rochester** We have searched for neutrons produced in an electrolytic cell filled with heavy water (D_2O) and having a Palladium cathode. We set a limit of 1 count/sec from 0.7 cm^3 of Pd, operated continuously for five days at a current of 2A. This limit is $4X10^4$ lower than the rate claimed by Pons and Fleischmann[1] for a similar cell.

* Submitted by A. C. Melissinos

** Supported by the DOE and the NSF.

[1] M. Fleischmann and S. Pons, paper submitted to Journal of Electroanalytical Chem., March 20, 1989.

(X) Special Session on Cold Fusion

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Late

Abstract Submitted
for the Baltimore, MD Meeting
of the
American Physical Society
1 - 4 May, 1989

REC'D.
APR 18 1989
A.P.S.

Physics and Astronomy
Classification Scheme
Number: 89

Suggested title of session in
which paper should be placed:
Special Session on Cold Fusion.

An Investigation of Cold Fusion using a Sensitive Neutron Detector. W.K. BROOKS, D.G. MARCHLENSKI, J.D. KALEN, M.S. ISLAM, M. KAITCHUCK, R. MCCREERY*, R.N. BOYD, P. HOLBROOKE, H. DYKE, The Ohio State University. -- A careful measurement of neutron production from a Pd electrode in an electrolytic cell has been performed. The neutron detection system consisted of a BC 501 liquid scintillator contained in a 4.0 cm thick, 18.5 cm dia. pyrex cylinder, surrounded by a plastic anticoincidence shield and lead housing. Pulse shape discrimination was used to identify neutron signals. This system yielded low backgrounds with approximately 1% counting efficiency. Initial results indicate no neutron production over a period of about 40 hours of counting. Estimates will be presented of how this may be compared to previous data. Further plans for more detailed studies of cold fusion will be described, including chemical analyses of the palladium electrode.

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REC'D.
APR 24 1989
A.P.S.

Abstract Submitted
for the Spring Meeting
of the
American Physical Society
May 1-4, 1989

PACS
Numbers 25.10+s, 25.45.-z, 96.30kf

Suggested title of session in which paper should be placed
Special Session on Cold Fusion

Cold Nuclear Fusion in Dense Metallic Hydrogen: Implications for Astrophysics. C.J. HOROWITZ, Nuclear Theory Center, Indiana U.*— The rate of nuclear fusion from tunnelling of zero point motion in very dense metallic hydrogen is calculated assuming a simple crystal of nuclei interacting via screened coulomb potentials. At a density of five g/cm^3 the fusion rate is 10^{-50} per H-D pair per second. Thus fusion may not contribute to the heating of Jupiter unless a more efficient mechanism is found. However increasing the density to 300 to 2600 g/cm^3 increases the rate to 10^{-21} to 10^{-12} sec^{-1}. It is speculated that a cold condensed object with a small amount of deuterium could be reheated via p + D cold fusion and start conventional thermonuclear fusion.

*Supported by the DOE.

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