Department of Energy
Office of Scientific and Technical Information
Post Office Box 62
Oak Ridge, Tennessee 37831

August 10, 2016

Re: OSTI-2016-01064-F

Dear Mr. Ravnitzky:
This is in final response to the request for information you sent to the Department of Energy (DOE), Office of Scientific and Technical Information (OSTI) under the Freedom of Information Act (FOIA), 5 U.S.C. 552 on June 22, 2016.

You requested a "copy of records, electronic, or otherwise, of each letter TO and FROM universities, companies, and organizations, from the OSTI 'cold fusion' documents collection." On July 11, 2016, you were emailed an interim response letter informing you of the need for OSTI to obtain release authorization from the Department of Energy. OSTI received notification to release the letters to you in their entirety on August 8, 2016. As a result, OSTI is releasing 72 cold fusion letters in this mailing on a CD-ROM because of the volume and file size of the PDFs.

In addition, there are approximately 13 letters that are currently being reviewed by the DOE's General Counsel Office (GC) for release or redaction. Upon receipt of guidance from GC, OSTI will release in whole or in part.

This decision, as well as the adequacy of the search, may be appealed within **90** calendar days from your receipt of this letter pursuant to 10 C.F.R. § 1004.8. Appeals should be addressed to Director, Office of Hearings and Appeals, HG-1, L'Enfant Plaza, U.S. Department of Energy, 1000 Independence Avenue, S.W., Washington, D.C. 20585-1615. The written appeal, including the envelope, must clearly indicate that a FOIA appeal is being made. You may also submit your appeal to OHA.filings@hq.doe.gov, including the phrase "Freedom of Information Appeal" in the subject line. The appeal must contain all of the elements required by 10 C.F.R. § 1004.8, including a copy of the determination letter. Thereafter, judicial review will be available to you in the Federal District Court either: 1) in the district where you reside; 2) where you have your principal place of business; 3) where DOE's records are situated; or 4) in the District of Columbia.

You may contact OSTI's FOIA Public Liaison, Charlene Luther, Office of Preservation and Technology at 865.576.1138 or by mail at the Department of Energy, Office of Scientific and Technical Information, 1 Science.gov Way, Oak Ridge, TN 37830 for any further assistance and to discuss any aspect of your request. Additionally, you may contact the Office of Government Information Services (OGIS) at the National Archives and Records Administration to inquire about the FOIA mediation services they offer.

The contact information for OGIS is as follows: Office of Government Information Services, National Archives and Records Administration, 8601 Adelphi Road-OGIS, College Park, Maryland 20740-6001, e-mail at ogis@nara.gov; telephone at 202-741-5770; toll free at 1-877-684-6448; or facsimile at 202-741-5769.

If you have any questions about the processing of the request or about this letter, please contact Madelyn M. Wilson at

Sincerely,

Madelyn M. Wilson
FOIA Officer
DOE OSTI
1 Science.gov Way
Oak Ridge, TN 37830

CF/Papers

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721 USA

COLLEGE OF ARTS AND SCIENCES
FACULTY OF SCIENCE
DEPARTMENT OF PHYSICS
BUILDING #81
(602) 621-6820

Dr. Ryszard Gajewski
US Dept of Energy/AEP

by FAX

August 31, 1989

Dear Ryszard:
Enclosed please find a preliminary note on our understanding of the question of tritium production in Cold Fusion.

It would be very kind of you if it would be possible for you to forward a copy of this note to ER-6, 3F-061 (William Woodard) as per their request of 9 August. As I have no FAX number for Dr. Bigeleisen, I also ask them to attend to any further distribution of this preliminary document, intended only for INTERNAL use by the committee.

Please limit distribution to official use only until submission for publication.

Yours Sincerely

Johann Rafelski
Professor of Physics

New Energy Times

New Energy Times

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

PRELIMINARY AZPH-TH/89-...

Comment on Tritium Production in Cold Fusion in Condensed Matter

David Harley and Johann Rafelski

Department of Physics
University of Arizona, Tucson, Arizona 85721

August 29, 1989

New Energy Times

Following on the first report of the observation of cold fusion neutrons in laboratory, [1,2], Fleischmann *et al*[3] have also claimed that anomalous amounts of tritium may be produced in this way. While their other measurments of heat and million times higher neutron yield than that of Jones' have been repeatedly criticized, there have been recently several reports supporting the third claim that tritium is produced during the electrolysis of heavy water [4,5,6,7]. In particular, Packham *et al* have presented experimental data that places a lower limit on the tritium production rate in two such experiments with palladium cathode and nickel anode, vis. their runs labelled 'A2' and 'A7', for which we estimate a lower limit on the tritium production rate of $5.2 \times 10^6 \mathrm{ml}^{-1}$of electrolyte $\mathrm{s}^{-1}$and $2.1 \times 10^8 \mathrm{ml}^{-1}\mathrm{s}^{-1}$ respectively. The same group concurrently measured the neutron flux during the experimental runs. In one electrolytical cell they obtain a neutron count of about one per second [8] which is about 10^6 less than the expected value derived from conventional deuteron-deuteron (dd) fusion, assuming symmetry between the neutron and tritium producing branches of the dd-fusion reaction. While the neutron count rate is consistent with the observation of 2.45 MeV fusion neutrons reported first by SE Jones *et al*[2], the reported tritium yield requires some phenomenon other than the one associated with the results of Jones *et al*. According to Wolf [8] it is very unlikely for the observed tritium abundance to have been from an impurity within the electrodes used in the experiments.

There are two points presented here in view of which make the tritium production perhaps even more mysterious than the excess heat reported. Firstly, the non-observation of neutrons severely limits the final-state triton energy due

to the possibility of a neutron producing deuterium-tritium (dt) secondary reaction. Secondly, the required smallness of this energy makes tritium production even less likely in an exit channel in which more than one charged particle is present (such as the proton-tritium (pt) exit channel of the dd reaction), due to the Coulomb suppression of such channels. These observations seem to imply that the only possible nuclear mechanism derives from some nuclear reaction *other* than dd, and we discuss all possible options without arriving at any satisfactory conclusion. Perhaps we should emphasize here that while we explore the consequences of energy and momentum conservation, which we presume to be sacred laws of physics, we are ignoring the fact that the lowest order quantum mechanical processes lead to rates for the processes we are discussing which are many orders of magnitude too small.

The constraint on the final state triton energy arises from the possibility of secondary fusion reactions being induced by high energy tritium produced in the 'cold fusion reaction'. It is well known that the dt reaction has an unusually large cross section that peaks at about 5 barn for a triton incident upon a deuterium target at an energy of about 70 KeV. The cross section is reduced to 2 barn at about 150 KeV, and falls off as $1/E_t$ at higher energies. If a high energy triton is produced in an environment containing substantial amounts of deuterium, it has a significant probability of undergoing a fusion reaction before being brought to rest. Specifically, the fraction of tritons of initial energy E that will fuse in a target is given by:

$$\frac{N_{fus}}{N_{inc}} \simeq \int_0^E dE' \frac{\sigma_{fus}(E')}{S(E')} \tag{1}$$

$\sigma_{fus}(E)$ is the energy dependent fusion cross section. $S(E)$ is the stopping power of the target, and at low energies is generally dominated by electron ionization processes that dissipate the incident charged particle's momentum. We have computed this fraction in manner similar to our prior treatment of the suggested fractal fusion [9] as function of the incident triton energy, using experimental data for the fusion cross section for d+t→ α(2.8 MeV)+n(14.8 MeV) [10] and computing $S(E)$ for t incident upon a PdD target using a standardized approach [11]. Despite the relative smallness of the fusion fraction (7.9×10^{-12} fusions per triton at 10 KeV, 1.7×10^{-9} at 20 KeV, and increasing to 2.7×10^{-8} at 100 KeV) the absolute yield of secondary neutrons we should expect to see turns out to be forbiddingly high. For t-energies as small as 100 KeV we find that the secondary neutron production rate should be of the order of 14 neu-

New Energy Times

trons ml^{-1}electrolyte s^{-1}(for run A2 of Packham), or 570 $ml^{-1}s^{-1}$(Run A7). For the less restrictive run (A7), only at a triton energy of 14 KeV does the secondary neutron flux begin to fall below the threshold of detectibility of neutrons (about $0.01s^{-1}$and assuming an electrolyte content of 10 ml). We assume in these estimates that all other neutron channels (such as from $d+d \rightarrow {}^3He+n$) are totally suppressed.

If tritium is indeed created with the required energy of less than about 20 KeV, then one can expect an asymmetry of greater than 50 : 1 favoring the unwanted neutron branch in the dd fusion reaction. This arises as a simple consequence of the appearance in the transition matrix element of not only the entrance channel wave function (containing the usual tunneling amplitude) but also the exit channel wave function, which in the case of the charged reaction products t+p being created at KeV energies will be suppressed due to the small amplitude of the Coulomb wave near to the nuclear channel radius in this exit channel. This effect is well known, such as in the Gamov description of α-radioactivity. Clearly, the ^3He+n channel does not suffer from this suppression, as there is no repulsive Coulomb force acting between the reaction products.

One may also wonder where the energy of fusion has gone, if tritons are formed at such small energies in the dd reaction. The only plausible answer is that such a reaction arises in association with the conversion of an electron, or a Bremsstrahlung photon. The phase space of the three final state particles favors equal momentum for each, but that implies that the momentum of the nuclei is only about 4 MeV/c. This corresponds to a very small energy for the triton, just a fraction of a KeV. While this is in accordance with the lack of secondary neutrons, such a tiny energy would lead to a strong branching into the neutron producing branch of the dd reaction because of the above- mentioned final state Coulomb effect. This observation is weakened to some degree by the possibility of (yet unexplained) long range neutron tunneling towards one of the deuterons, but one would expect such a process to produce energetic tritons.

Thus if indeed the tritium observed is due to cold fusion, we must find another nuclear reaction which will form tritons at just the "right" energy of about 20 KeV, higher energies being forbidden by absence of secondary neutrons, lower energies being made implausible by final state Coulomb suppression. We therefore turn now to consider all possible tritium producing, deuterium induced nuclear reactions, accessible in cold fusion. The number of direct exothermic

New Energy Times

(positive Q-value) nuclear reactions involving a deuterium reacting with a stable or sufficiently long lived nucleus with nucleon number (A), resulting in tritium and a nucleus (A−1), is indeed severely limited; in fact, a survey of all such exothermic reactions using available nuclear and atomic mass tables [12] reveals just fifteen such possibilities, and two other candidates with small endothermic reaction energy (negative Q-values) which could possibly change sign after reevaluation of the experimental data. The two exothermic reactions:

$$d+^{183}W \rightarrow t+^{182}W \ (Q=46\pm4 \text{ KeV}) \text{ and particularly}$$
$$d+^{201}Hg \rightarrow t+^{200}Hg \ (Q=19\pm6 \text{ KeV})$$

are the only two known reactions with a $Q-$value of less than 100 KeV. The other 13 reactions, aside from the usual dd case, are:

$d+^{6}Li$ (Q=2.557 MeV for the α+n+t channel);
$d+^{9}Be$ (Q=4.592 MeV);
$d+^{13}C$ (Q=1.311 MeV);
$d+^{17}O$ (Q=2.114 MeV);
$d+^{143}Nd$ (Q=133 KeV);
$d+^{145}Nd$ (Q=302 KeV);
$d+^{149}Sm$ (Q=385 KeV);
$d+^{179}Hf$ (Q=157 KeV);
$d+^{189}Os$ (Q=336 KeV);
$d+^{195}Pt$ (Q=152 KeV);
$d+^{235}U$ (Q=959 KeV);
$d+^{238}U$ (Q=105 KeV).

None of these 13 more energetic reactions can proceed via a small Q-value to an excited intermediate state in the daughter nucleus. The nuclear mass data currently available further shows that $d+^{163}Dy$ has an adopted Q-value of Q=−14±4 KeV, having been listed at earlier times as Q=5 KeV. Another case, $d+^{176}Lu$ has been listed with Q=66 KeV in older mass tables, but today the adopted value is Q=−36 KeV.

Thus if tritium is produced without the presence of a much larger neutron signature, we must conclude that a (d,t) reaction on a heavy nucleus has taken place by some unknown mechanism with the best candidate being the reaction involving ^{201}Hg (13.6natural relative abundance, resulting in a triton of 19±6 KeV, just barely within the tolerable limit for neutron production by

New Energy Times

secondary reactions. (Other such good candidates are ^{183}W (14.3% natural abundance) and perhaps also ^{163}Dy (24.9%).) In view of the obstacles to such a reaction and the preceding discussion we however conclude that the process of tritium production without accompanying neutron yield gives rise to even a greater scientific mystery as the purported anomalous heat effect.

Acknowledgement This research has been supported by the US Department of Energy, Division of Advanced Energy Projects.

References

[1] Jones, S.E. *Bulletin of the American Physical Society* **34**, 1228 (1989).

[2] Jones, S.E., Palmer, E.P., Czirr, J.B., Decker, D.L., Jensen, G.L., Thorne, J.M., Taylor, S.F. and Rafelski, J. *Nature* **338**, 737 (1989).

[3] Fleischmann, M., Pons, S. and M. Hawkins "Electrochemically Induced Nuclear Fusion of Deuterium", *J. Electroanal. Chem.* **261**, 301 (1989) and erratum.

[4] Packham, N.J.C., Wolf, K.L., Wass, J.C., Kainthla, R.C. and Bockris, J.O.M. "Production of Tritium from D_2) Electrolysis at a Palladium Cathode", Texas A&M preprint; K.L. Wolf, private communication.

[5] Storms, E.K., Talcott, C., public announcement of tritium observations at the level of 2×10^{12} tritons $ml^{-1}$of electrolyte, a level comparable to that of Packham [4].

[6] Sanchez, C., Sevilla, J., Escarpizo, B., Fernandez, F.J. and Canizares, J. "Nuclear Products Detection During Electrolysis of Heavy Water with Ti and Pt Electrodes" Universitad Autonoma de Madrid preprint, to appear in *Solid State Comm.*.

[7] Iyengar, P.K., "Cold Fusion Results from BARC Experiments", Presented at the Emerging Nuclear Energy Systems (ICENES V), Karlsruhe, Germany, to appear in Proceedings (World Scientific, Singapore).

[8] Wolf, K.L., Packham, N.J.C., Lawson, D.L., Shoemaker, J., Cheng, F. and Wass J.C. "Neutron Emission and the Tritium Content Associated with

New Energy Times

Deuterium Loaded Palladium and Titanium Metals", presented at May 23-25 1989 cold fusion meeting in Santa Fe, New Mexico and preprint.

[9] Harley, D., Gajda, M. and Rafelski, J."Review of the Current Status of Cold Fusion", Arizona Preprint AZPH- TH/89-60, presented at the NATO Summer Institute on Nuclear Equations of State, Peniscola, Spain, May 28, 1989, to appear in proceedings , Plenum. Pub. Co, W. Greiner, editor; and Harley, D., Gajda, M. and Rafelski, J."Review of the Current Theoretical Status of Cold Fusion", Arizona Preprint AZPH-TH/89-61, presented at the ICENES V, Karlsruhe, W. Germany, to appear in proceedings, World Scientific, Singapore.

[10] Jarmie, N., Hardekopf, R. A., *Phys. Rev. C* **29**, 2031 (1984) and Los Alamos preprint.

[11] Ziegler, J.F., Biersack, J.P. and Littmark, U. "The Stopping and Ranges of Ions in Solids", Pergamon Press (1985).

[12] Wapstra, A.H. and Audi, G. *Nucl. Phys* **A432**, 1 (1985).

New Energy Times