Experimental Studies Supporting the Transmission Resonance Model for Cold Fusion in Light Water: II Correlation of X-Ray Emission with Excess Power

R.T. BUSH and R. D. EAGLETON
Physics Department
California State Polytechnic University
3801 West temple Avenue, Pomona, CA, USA

ABSTRACT: Part I[3] presented evidence in support of Bush's TRM Model[1,2,4] and, in particular, his hypothesis of "alkali-hydrogen fusion" in a lattice as a prototype for cold fusion with both light and heavy water[2]. In Part II preliminary evidence is presented for x-ray emission accompanying both the heavy and light water excess heat effects in the form of both characteristic x-rays and bremmstrahlung. These studies had the unsatisfactory feature of low signal-to-noise, but the satisfactory features of reasonable statistics and excellent correlation. An interesting feature was that x-ray emission decreased somewhat after a cell was switched off, but then spiked upward to decay exponentially to the background level over a period of days. This emission was apparently associated with the desorption of hydrogen from the cathode. With the cell turned off it was also possible to study x-ray emission accompanying the thermal desorption of hydrogen by changing the cell temperature and studying x-ray emission as a function of cathode surface temperature. When this effect of x-rays accompanying desorption was factored in, Bush's TRM Model[1,2,4] appears to account for the correlation between x-ray emission and excess power.

1. Introduction:

Copious amounts of radiation, either in the form of neutrons or radiation , have not been reported in the case of either heavy water cold fusion cells (Fleischmann-Pons[5]) or light water cold fusion cells (Mills[6]), and this has been a puzzle. Bush points out that his TRM Model incorporating the hypothesis of "alkali-hydrogen fusion" in a lattice offers a solution to this puzzle: Thus, if much, or all, of the excitation energy goes into the kinetic energy of the product particle; e.g. a calcium nucleus in the case of a potassium nucleus adding a proton at, or just inside, the surface of a nickel lattice, one would expect radiation in the form of characteristic x-rays and bremmstrahlung, but no neutrons or gamma rays, which are far more penetrating. So, where are the x-rays? Tantalizing evidence has been achieved by researchers such as Miles and Ben Bush[7], who have had one instance in which a dental film placed inside a heavy water cell showed fogging in a case in which the cell was also known to be evidencing excess heat. In addition, Srinivasan[8] has seen evidence of extraordinary electron fluxes in cases of palladium and titanium loaded with either deuterium or hydrogen electrolytically or by gas-loading. It was primarily private communications from these two groups that encouraged Bush to look for x-rays with cells designed by Bush and Eagleton and built by Eagleton.

A limitation was that only one scintillation counter was available. Additionally, the emission was meager enough that it would not fog dental film positioned against the outer Styrofoam surfaces even for many days. However, by placing a scintillation tube on top of the cell, or as close as possible along side at the same height as the cathode (This orientation usually gave he best counting rates.) it was possible to attain data in support of the existence of both characteristic x-rays and bremmstrahlung and, also, to see two basic x-ray effects: 1. Qualitative and quantitative correlation of x-ray emission with excess power. 2. Qualitative and quantitative correlation of x-ray emission associated with the desorption of hydrogen from the cathode. The weight of the evidence provides support for Bush's three dimensional TRM Model[1,2,4] (Transmission Resonance Model). An unsatisfactory feature of these preliminary studies was the low signal-to-noise ratio of the data, which meant that one must often count for long periods of time (hours or days). (This aspect is apparently consistent with those studies in which previous experimentalists anticipated seeing a readily-measurable effect.) However, a significant ameliorating feature was that, whereas characteristic x-rays required days of counting and then about half that of background subtraction at relatively low excess power to see, correlations of x-ray emission with excess power could be observed for cases in which each x-ray data point required only about fifteen minutes, provided that the counts from many channels of a multi-channel analyzer were added together to establish a single data point. Thus, the sum of the counts resulting from bremmstrahlung and numerous characteristic x-rays was employed to establish a single data point. This enabled the pattern of x-ray data points to be correlated either qualitatively, or quantitatively, with the excess power data achieved with the calorimeter. The result was that poor signal-to-noise was considerably compensated by reasonable statistics and a high correlation resulting in a high level of confidence in the results. Reproducibility also appeared to be good.

2. Apparatus:

The electrolytic cell (light water case), calorimeter, and computerized data acquisition system were described in Part I[3]. For the heavy water cell the anode-cathode configuration (platinum wire anode-palladium cathode) of the cell was close to that of Fleischmann-Pons[5]. X-ray measurements were performed using a Bicron 1.5 inch diameter NaI scintillation detector. An 811-3 multichannel analyzer PC board and software by Nucleus, Inc. of Oak Ridge, Tennessee were employed by Bush for x-ray counting.

3. Experiments with a Heavy Water Cell (Cell 58):

The electrolytic cell chosen for the initial studies attempting to correlate x-ray emission and excess heat, cell 58, had a cathode consisting of a (77% Pd/23% Ag)-alloy fabricated by Storms of Los Alamos. The platinum wire anode was wrapped uniformly around this thin flat cathode ala Takahashi. It took about 16 days of charging to produce any excess heat, with much current ramping along the way. Approximately 3 W was the highest excess power observed. (Cathode surface area: 4 cm^2. An unusual feature was that the electrolyte was 0.85M LiOD.)

Discovery of x-ray emission-vs.-current density fine structure mirroring that for excess power vs. current density and predicted by Bush's TRM Model.

Fig. 1 portrays this situation for which calorimetric data and x-ray data were taken simultaneously, and show a strong correlation based upon the similarity of the typical "hill-and-valley" curve familiar from Bush's TRM Model. If the charged product nucleus is given kinetic energy, and/or if electrons present are given some of the excess energy, x-rays should be produced due to the deceleration of the charges. Data points were the result of summing the results of a large number of energy channels.

Characteristic x-ray lines were observed:

Fig. 2 and Fig. 3 show apparent characteristic x-ray lines associated with platinum: Since the anode is of Pt, and part of this plates onto the cathode during electrolysis, this should not be surprising. Fig. 2 shows a characteristic Pt x-ray line centered at about channel 316 corresponding closely to the known energy of 75.6 keV. [Correspondence of the energies and channels was established via a calibration curve employing characteristic lines for such sources as Cs137 (32 keV x-ray line) and Co57 (122keV line).] Fig. 3 shows an apparent doublet of Pt x-ray lines centered at approximately the channels 272 and 280, corresponding, respectively, to the known Pt x-ray line energies of 65.1 keV and 66.8 keV. In all three cases note the reasonable Gaussian line shape. Fig. 4 is quite interesting: Apparent characteristic palladium x-ray lines centered at approximately channels 90,100, and 105 corresponding, respectively, to the known energies of about 21.1 keV, 23.8 keV, and 24.3 keV. Characteristic lines identified as those of silver are shown centered at channels 93, 107, and 109, corresponding, respectively, to the known Ag lines of 22.1 keV, 25.0 keV, and 25.5 keV. In addition, other lines in Fig. 4 have been identified as being associated with plausible typical impurities of Pd and Pt: A ruthenium peak is seen centered at about channel 82 corresponding to the known energy of about 19.2 keV, and a rhodium peak is centered at about channel 87 corresponding to the known energy of about 20.1 keV. Apparently, then, the excess heat effect can be employed in conjunction with an x-ray counter and multi-channel analyzer to determine the presence of major metal impurities. Also, the presence of the x-rays (keV range) provides evidence of nuclear processes. With regard to x-rays potentially associated with energetic electrons, two possibilities suggest themselves: These electrons may result from internal conversion. Also, perhaps these are the electrons effecting the nuclear reaction via shielding, as in the case of the a "s-electrons" suggested by Bush[2].

After cell 58 was turned off, the x-ray counting rate initially decreased several percent for about a day and then spiked up in the time of about a day to a peak about 12% higher than when the cell was operating. The counting rate then decayed exponentially over a period of about nine days to the apparent background level later established by removing the cathode from the cell.

This behavior is seen from Fig. 5 and apparently is a different x-ray emission effect in that it is associated with the desorption of the deuterons from the cathode.

Based upon the finding of x-rays with a switched-off cell, Bush realized the possibility of looking for temperature-dependent x-ray emission peaks (sum of counts from large number of different channels) associated with the thermal desorption of deuterons.

Fig. 6 shows that the first attempt at this was reasonably successful. The solid curve is based upon Bush's TRM Model. The latter predicts this temperature dependence in the same manner that it predicts the temperature dependence for neutron emission in the case of the thermal desorption of deuterons; e.g. recall the well known -30 C line established for neutron emission. Thus, with an electrolytic cell in which the cell, and thus cathode, can be heated by heating the bath, x-ray, and probably neutron, temperature-dependent studies can be conducted by simply switching off the current as an alternative to more "conventional" calorimetric experiments. With reference to Fig. 6, it is absolutely mind-boggling that minor temperature changes of the cathode, e.g. going from 32C to 23.4C in this case, can result in a major increase in the real x-ray intensity.

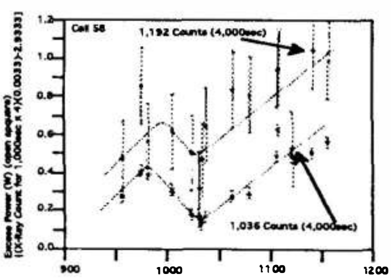


Figure 1. Excess Power 7 X-Ray Count vs Currentt

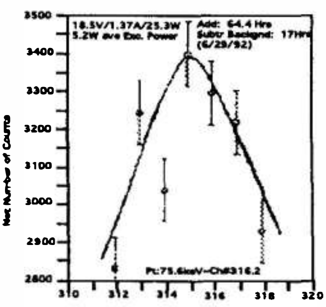


Figure 2. Net Counts vs. Channel Number.

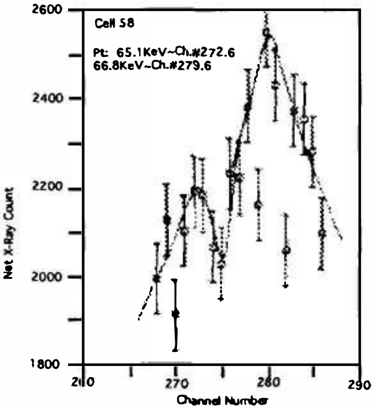


Figure 3. X-Ray Count vs. Channel Number

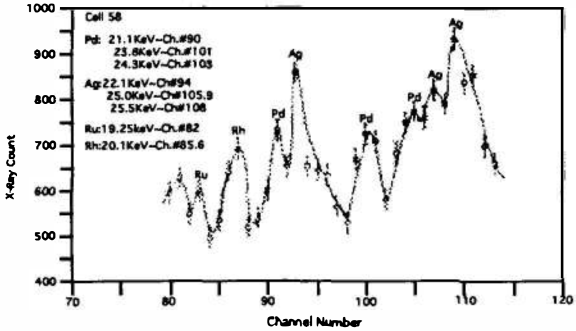


Figure 4. X-Ray Count vs. Channel Number

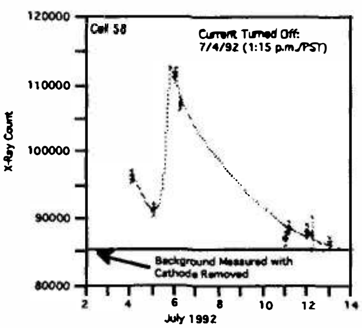


Figure 5. X-Ray Decay After Cell Turned Off

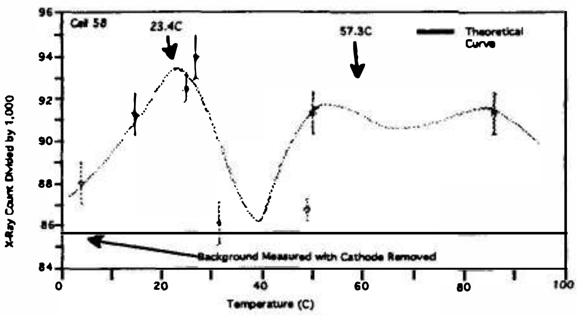
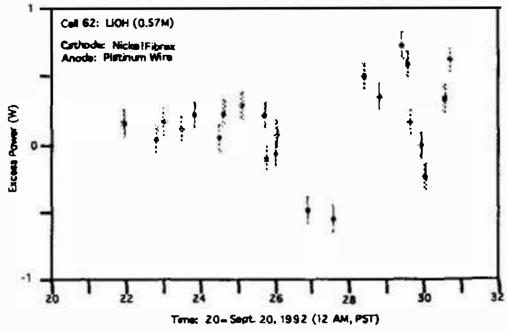


Figure 6. X-Ray Count: Thermal Desorption of Deuterons

4. Experiments with a Light Water Cell (Cell 62):

Cell 62 was a light water based 0.57M LiOH cell with the inside out anode-cathode configuration described in Part I[3] with the thin annulus (approx. 1 mm) of the cathode composed of sponge nickel (nickel fibrex).

Fig. 7 and Fig. 8, respectively, show a qualitative correlation between excess power and x-ray emission over a period of days at relatively low excess power. Apparent discrepancies in that correspondence can be accounted for by the x-ray emission effect associated with hydrogen desorption when the current (applied power) is very low, or off. Fig. 9 has the excess power and x-ray count data points included on the same plot. For this higher excess power range one again sees a qualitative correlation between excess power and x-ray emission, but in a higher excess power range. Finally, Fig. 10 exhibits the roughly linear relation between real x-ray count (actual count minus background) and excess power for this light water cell. (In cases where two real x-ray counts were the same, the excess powers were averaged to establish the point.)



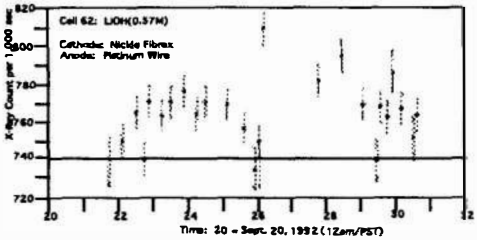


Figure 8. X-Ray Count vs. Time.

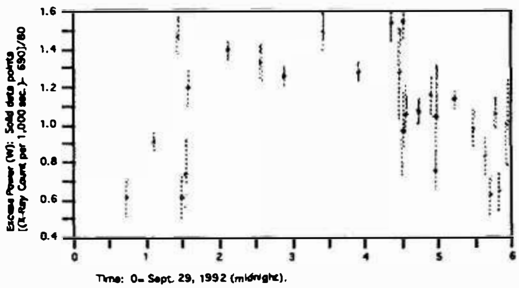


Figure 9. Experimental Correlation Between X-Ray Count and Excess Power

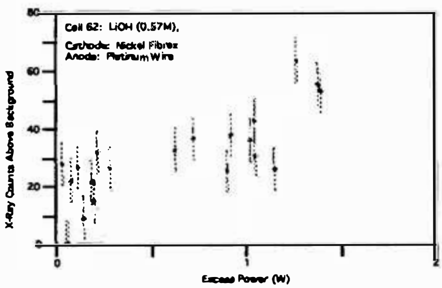


Figure 10. Real X-Ray Count vs. Excess Power

5. Conclusions:

In the case of heavy water cells with palladium cathodes it might be supposed that microcracking of the palladium results in high electric fields, with the resulting accelerated charged particles yielding x-rays upon deceleration. However, this argument could hardly be applied to the light water case, since the nickel cathode is presumably undergoing no microcracking. Applying Occam's razor suggests, then, that x-rays in the Pd case do not arise from microcracking. We conclude from these studies that x-rays have been systematically observed and studied, perhaps for the first time, for both the heavy - and light water cases and correlated with excess power. These studies strengthen the argument that the light water and heavy water excess heat effects are, indeed, nuclear effects. Coupled with the evidence adduced in Part I[3], we conclude that they also strengthen the case for Bush's hypothesis[2] of "cold fusion" as "alkali-hydrogen fusion" in a metal lattice, or as CAF ("Cold Alkali Fusion") (Suggested to Bush by Drexler[9].).

Acknowledgments

It is a pleasure to acknowledge Roger Bush, son of R.T. Bush, whose ingenious contributions have made possible our computerized data acquisition system. Pete Siegel of the Cal Poly Physics Department is thanked for help with the x-ray equipment and for encouraging Bush's search for x-rays. Hal Fox is appreciated for Dr. Eagleton's financial support for the Nagoya Conference and for his enthusiastic support of the Cal Poly Cold Fusion Project. Joe Ignat is thanked for providing funding for Dr. Bush to attend the Nagoya Conference, and for his general support and encouragement of our project. Tim Shoemaker is appreciated for his help in assembling the manuscripts. Southern California Edison, Inc. of Rosemead, CA, is especially thanked for their funding of our research. N.J. Kertamus of S.C.E. is thanked, in particular, for his interest and support. N. Srinivasan, Head of the Neutron Physics Division, B.A.R.C., Bombay India, has been especially encouraging of the Cal Poly research effort. Finally, we wish to thank H. Ikegami, Chairman, Secretariat, ICCF3, for his leadership in the planning of the Nagoya Conference. (These acknowledgments also apply to Part I[3].)

References

1. R. Bush, "'Cold Fusion': The Transmission Resonance Model Fits Data on Excess Heat, Predicts Optimal Trigger Points, and Suggests Nuclear Reaction Scenarios," Fusion Technol., **19**, 313 (1991).
2. R. Bush, "A Light Water Excess Heat Reaction Suggests That 'Cold Fusion' May Be 'Alkali-Hydrogen Fusion'," Fusion Technol.,**22**, 301(1992).

3. R. Bush and R. Eagleton, "Experiments Supporting the Transmission Resonance Model for Cold Fusion in Light Water. II. Correlation of X-Ray Emission With Excess Power", Proceedings of the Third Annual Conference on Cold Fusion, Nagoya, Japan, Oct. 21-25, 1992.
4. R. Eagleton and R. Bush, "Calorimetric Evidence Supporting the Transmission Resonance Model for Cold Fusion", Fusion Technol., **20**, 239 (1991).
5. M. Fleischmann and S. Pons, "Electrochemically Induced Nuclear Fusion of Deuterium," J. Electroanal. Chem., **261**, 301 (1989).
6. R. Mills and K. Kneizys, "Excess Heat Production by the Electrolysis of an Aqueous Potassium Carbonate Electrolyte and the Implications for Cold Fusion," Fusion Technol., **20**, 65 (1991).
7. M. Miles and B. Bush (China Lake, CA), Private Communication, May 1992.
8. M. Srinivasan (BARC, Bombay, India), Private Communication, May 1992.
9. J. Drexler, Private Communication, October 1992.