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2017-05-03: Cause opposing currents of protons/deuterons & electrons in superconducting hydride, using a mechanical generator

Wednesday, 3 May 2017, 6:38 pm
For most of my life, since I first learned of the concept, perhaps in high school, I have been fascinated with fusion.

This afternoon, while trying to recover from a severe cold, I took a nap. Shortly before I awakened, I had a dream that may provide a way forward.

An alloy needs to be developed that can incorporate large quantities of hydrogen (or deuterium?) and that is superconducting at a convenient temperature. Start with one that is superconducting in liquid nitrogen (77K), but it will be best to develop one that is superconducting at room temperature (25 C / 298K).

Wind a generator with this alloy, with permanent magnets in the rotor with two poles (for 2-phase power) or six poles (for 3-phase power). Charge the generator with high pressure hydrogen (or deuterium?). The rotor is equipped with permanent magnets. As the rotor turns opposing currents of electrons and protons are induced in the alloy. Fusion will greatly multiply the output current, possibly by a factor of many thousand.

Eventually the produced helium will need to be separated by circulating the hydrogen through a silver-palladium purifier.

I believe that the wire will have to be a single crystal. This can be obtained by forcing the melt through a long, tapered funnel which gradually cools, to its tip, below the freezing point of the alloy. The friction generated in the solidifying alloy will align the crystal as it freezes.

[signed by creating a password for this file; Wttogfap] H. Tracy Hall, Jr.] 6:54 pm
- - -

2017-05-04: Induce opposing currents with a transformer

Thursday, 4 May 2017, 7:03 am

It occurred to me last night that current could be induced in a superconducting coil by configuring it as a transformer, as well as by a mechanical generator. But superconductors exclude magnetic fields. How can a superconducting transformer exist?

I just did an Internet search and learned that they do, in fact, exist, and have been extensively tested for power transformer applications. This is a useful reference:

WTEC (World Technology Evaluation Center) Panel Report on
Power Applications of Superconductivity in Japan and Germany
http://www.wtec.org/loyola/scpa/toc.htm
[edit 2022-02-04: updated link: http://scienceus.org/wtec/old/scpa.pdf dated Sep 1997]

3. Power Transmission and Distribution Cables & Transformers
[edit 2022-02-04: p. 27 in above link]
Robert S. Sokolowski
Introduction
Superconducting Power Transmission Cables -- Overview
HTS Power Transmission Cables - Overview
HTS Power Transmission Cable Development in Japan
Superconducting Transformers -- Overview
HTS Transformers -- Overview
HTS Transformer Development in Japan
References
signed: 7:09 am
- - -

2017-05-06: Driving frequency

Saturday May 6, 2017, 9:44 am

There may be a resonant frequency at which the protons and cooper-pair electrons in the hydrogen-filled superconductor need to be driven: it might be in the GHz range.

[signed] 9:45 am
- - -

2017-09-06: Superconductivity in PdH and PdD

Wednesday, 6 September 2017, 5:02 pm
Fires are burning throughout the west, and the full moon is orange. I awakened to a sound I haven't heard in a long time – coyotes in the surrounding hills howling at each other. It sounded like there might be some coyotes even closer, in the meadow (Canyon Meadows, where we live: 9090 Meadow Drive, Provo Canyon, Wasatch County, Utah 84604).

Yesterday I awakened with the vague memory that I had read somewhere that palladium-hydrogen is a superconductor. Indeed, it is, and recently it has been found that it can be superconducting to temperatures as high as 52-61 K, approaching liquid nitrogen temperature (77K).
- - -
https://arxiv.org/abs/1608.01774
PDF: https://arxiv.org/ftp/arxiv/papers/1608/1608.01774.pdf

Superconductivity in PdH: H. M. Syed, T. J. Gould, C. J. Webb and E. MacA. Gray*

Queensland Micro- and Nanotechnology Centre, Griffith University, Nathan 4111, Brisbane, Australia
*e-mail: e.gray@griffith.edu.au
(Submitted on 5 Aug 2016)

"We report the observation of conventional superconductivity at the highest temperature yet attained without mechanical compression, around 54 kelvin in palladium-hydride and 60 kelvin in palladium-deuteride. The remarkable increase in Tc compared to the previously known value was achieved by rapidly cooling the hydride and deuteride after loading with hydrogen or deuterium at elevated temperature. Our results encourage hope that conventional superconductivity under ambient conditions will be discovered in materials with very high hydrogen density, as predicted more than a decade ago.
Comments: 15 pages; 4 figures
Subjects: Superconductivity (cond-mat.supr-con)
Cite as: arXiv:1608.01774 [cond-mat.supr-con]
(or arXiv:1608.01774v1 [cond-mat.supr-con] for this version)
. . .
"PdHx is superconducting[1] for $0.7 < x$ 1.0, with Tc = 8− 10 K for x ≈1.0 confirmed in many experiments[11]. Palladium deuteride, PdDx, exhibits a reverse isotope effect[2], with Tc= 8-10K 12 for x ≈1.0 confirmed in many experiments[11]
. . .
"Pd metal readily absorbs hydrogen at room temperature and less than 0.1 MPa gas pressure. [1 MPa = 10 bar; 0.1 MPa = 1 bar ~ 15psi] H/D occupies octahedral (oct) interstitial sites in the face-centered cubic Pd lattice. At first a solid solution, the α phase, is formed. As the hydrogen pressure increases, the concentrated β phase, PdH0.6 is formed. The phase transformation is accompanied by lattice expansion and decrease of the magnetic susceptibility as the hole in the Pd d band is filled. The lattice mismatch between the α and β phases causes the generation of dislocations[25]

"For experiments on superconductivity at low temperatures, PdHx/Dx typically has been prepared by electrolysing Pd at room temperature and cooling rapidly to cryogenic temperatures to minimise H/D loss following removal from the electrolysis cell[11] This procedure involves passage through the two-phase region and so leaves the sample with a high concentration of dislocations. The role, if any, of dislocations in superconductivity in PdHx/Dx is not clear, although it has been proposed [26] that filamentary superconductivity may occur within dislocation cores."

Filamentary superconductivity may occur within dislocation cores.

. . .
[1] T. Skoskiewicz, Phys. Status Solidi A 11, K123 (1972).
[2] B. Stritzker and W. Buckel, Z Physik 257, 1 (1972).
[11] H. M. Syed, C. J. Webb, and E. MacA. Gray, Prog. Solid State Chem. 44, 20 (2016)
[25] Y. Fukai, The Metal-Hydrogen System, Basic Bulk Properties (Springer, 2005), 2d edn.
[26] A. Lipson, B. J. Heuser, C. Castano, G. Miley, B. Lyakhov, and A. Mitin, Phys. Rev. B 72, 212507 (2005).

My summary of their experiment:
Cylindrical pressure cell, 12.7 mm dia, 1.2 m long, upper portion 316 stainless steel, lower portion, inserted in furnace & cryostat, was stronger 660 stainless steel. Internal diameter 10 mm.
H2 & D2 sources: metal hydrides. Pressure maintained throughout experiment, meaning that there will be flow into and out of the sample.
Sample: Pd wire .5 mm x 80mm, formed in serpentine fashion on a alumina substrate, copper leads spot-welded on. Platinum resistance thermometer: Lakeshore Cryotronics Pt102, using DIN IEC 751 Temperature/Resistance table for platinum sensors.
Anneal 500 C under vacuum 8 hours, then heat to 300C and loaded with H2 or D2 gas, pressure: 10 MPa (1450.38 PSI). Pre-cool lower portion in liquid nitrogen, then transfer to cryostat.
Cryostat: Cryogenics Limited cryostat cooled by a two-stage closed-cycle refrigerator and cooled "as fast as possible."
"The base sample temperature reached with the pressure cell inserted was approx. 40 K."
(Apparently one of these, though they are rated to 4 K:
http://www.cryogenic.co.uk/products/cryocoolers)
Resistivity was measured during rapid heating to room temperature, taking about 30 minutes.
"the estimated equilibrium H/D content was x ≈ 0.95 [29] "
[29] R. Griessen, N. Strohfeldt, and H. Giessen, Nat. Mater. 15, 311 (2016).
Link to view full article from Nature materials: http://rdcu.be/eUwO (can't be saved)
http://www.nature.com/nmat/journal/v15/n3/full/nmat4480.html [abstract]
supplementary material:
https://www.researchgate.net/profile/Nikolai_Strohfeldt/publication/284156204_Supporting_Information_to_Thermodynamics_of_the_hybrid_interaction_of_hydrogen_with_palladium_nanoparticles/data/564c7f3408ae020ae9faadfd/nmat4480-s1.pdf [saved to this folder as nmat4480-s1.pdf; these links to ref {29} above were inserted 1017-10-11]

"Both rapid cooling and rapid heating were necessary to observe the superconducting transition."
"It would be surprising, however, if higher values of Tc were not observed in previous work, since cooling times from room temperature to 40 K and below comparable to, and even shorter than, the cooling time in the present experiments would have been possible."

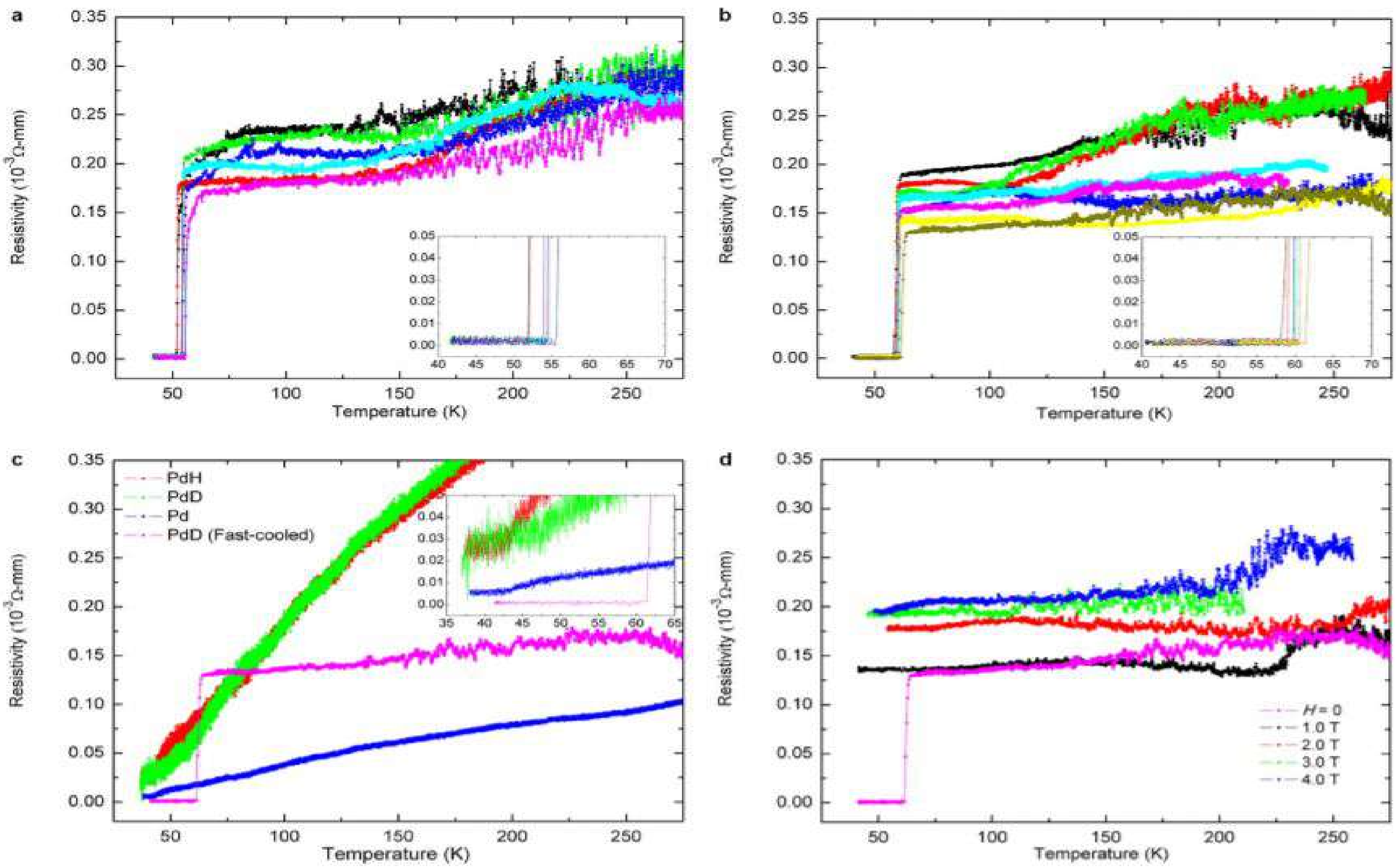
System was calibrated with copper wire, demonstrating reproducibility and lack of artifacts.
Zero resistance below ~54K for hydride and below ~60K for the deuteride.
Note from the figure that H or D greatly increases the resistivity at all temperatures above the superconducting transition.

A high magnetic field (1 T) quenches superconductivity) Neodymium magnets (Nd2Fe14B have a remanance, Br) of about 1 to 1.4 Tesla) https://en.wikipedia.org/wiki/Neodymium_magnet
Resistivity rises with increasing field (Fig. 1d)

The effect is not always observed, and the success rate was higher with D than with H. (**Note that the Fleischmann-Pons effect is very elusive: I speculate that it is because a high-temperature superconducting phase has to be induced.**)

The low-temperature superconducting phase has been extensively studied: it is due to nearly complete filling of the octahedral sites in the Pd lattice. The authors believe that the high temperature effect occurs when the tetrahedral sites begin to be occupied. This is a non-equilibrium state that anneals out upon slow cooling or heating.

Monday, 9 Oct 2017
I've spent the day learning more about superconductivity in PdH & PdD



"Figure 2. Resistivities of wire samples loaded with hydrogen/deuterium 300°C and cooled to approx. 40 K before measurement while heating to 300 K.
(a) PdHx rapidly cooled and rapidly heated. Superconductivity was observed below about 54 K.
(b) PdDx rapidly cooled and rapidly heated. Superconductivity was observed below about 60 K. Note the higher transition temperature compared to the hydride.
(c) PdHx, PdDx and pure Pd, all cooled slowly and heated slowly, compared to rapidly cooled and rapidly heated PdDx. Note in the latter case the transition to a state with lower resistivity than the pure metal. Note also the smooth variation of resistivity with temperature and the high contribution of H/D to the resistivity.
(d) PdDx rapidly cooled and rapidly heated in a magnetic field as indicated. Note the quenching of the superconducting transition by the magnetic field."

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"We propose that the high-temperature hydrogen configuration is not purely octahedral (oct), and it has been concluded from neutron diffraction studies[38] that significant tetrahedral (tet) D occupancy occurs at 300 °C. In this case it is feasible that some tet H/D is preserved at 40 K by rapid cooling. The need for rapid heating to observe the superconducting transition is then easy to understand: diffusion of H/D would drive the system towards the equilibrium configuration, which at room temperature and below is oct occupancy[38]. "

[38] K. G. McLennan, E. MacA. Gray, and J. F. Dobson, Phys. Rev. B 78, 014104 (2008).

The authors believe that the superconducting phase may be only a very tiny percentage, by volume, of the bulk phase, and that success is achieved only when a complete path occurs that connects the isolated regions or filaments of the phase.

"Aside from imperfections in the electrical connections to the sample, the resistance of a macroscopic sample will be zero if there is a continuous network of superconducting material between the two ends, even if the majority of the sample remains normal. The somewhat random occurrence or non-occurrence of a transition to zero resistivity suggests that the superconducting network is either continuous or broken, as in the percolation phenomenon in which the gross conductivity of a three-dimensional network of conducting elements is suddenly lost at a critical fraction of broken connections[40]. In three dimensions, the percolation threshold is very roughly 30%. We can then understand unsuccessful experiments as those in which, owing to the numerous variable experimental factors, the percolation threshold was not reached.

"These ideas lead to an explanation of why was superconductivity was not always observed when the sample was cooled and heated quickly. The success rate with deuterium loading was much higher than with hydrogen. In unsuccessful trials, i.e. those in which the superconducting transition was not observed, once again, the resistivity varied wildly with temperature, and between trials (Fig. 3). Once again, this could indicate an inhomogeneous state, but one in which the sample as a whole does not reach a state of zero resistance. A further point is that in all cases where the sample was cooled and heated quickly (Fig. 2(a), (b), (d); Fig. 3), the resistivity at room temperature was no more than about half its equilibrium value (Fig. 2(c)), whether or not the superconducting transition was observed. This shows that the sample was always very far from equilibrium, even at room temperature, after rapid cooling and heating, supporting the idea that a non-equilibrium state has been frozen-in by rapid cooling from 300 °C and is prevented from transforming to the equilibrium state by the limited diffusion rates of H and D at cryogenic temperatures, with the slower diffusion of D allowing percolation of the gross superconducting state more reliably."
= = =

The fact that the Fleischmann-Pons effect occurs at all indicates, to me, that a superconducting state is, in fact, achievable in PdD at room temperature and above. It is probable that the volumetric fraction of material in this state is minuscule. Here is a possible way to increase that loading:

[**Edit 2022-02-25, 7:24 am:**
It occurs to me that the starting temperature could be increased, the operating pressure increased, and the speed of cooling increased, by using a stronger tube. The mass of the sample itself should be decreased as much as possible, and it should be equipped with an electrical resistance heater that can take the sample clear up to the annealing temperature of Pd, around 1000°C, The sample should be surrounded by several closely-spaced polished heat shields to minimize heat transfer to the pressure vessel by convection and radiation. The pressure vessel is immersed in liquid nitrogen while the sample is annealed under vacuum and then pressureized, perhaps to 20 Mpa (~3,000 psi, a pressure typical of commercial gas cylinders). The heat shields are then rapidly retracted to quench the sample under pressure. Perhaps under these conditions, superconductivity will be observed at 77 K. If not, then the quenching can continue, albeit at a slower pace, to the 40K cryostat.}
[end of edit, 2022-02-25, 8:01 a.m.]

Experiment 1: Charge (electrolytically or via glow discharge) a coil of fine Pd wire, then quench.

1. Wind a coil of very fine Pd wire: perhaps 0.1 mm in diameter, on an open insulating structure, on a thin-walled, threaded alumina spool, the threads being deep and the wire being loose in the threads to avoid strain due to differential thermal expansion. Spot weld 4-point resistivity leads.
2. Anneal in vacuum for at least 8 hours, 500 C
3. Cool to room temperature and charge with D in a Fleischmann-Pons setup to the highest loading possible, but at a temperature just above the freezing point of the solution, to avoid annealing. Monitor resistance continuously through this and all following stages.

4. Quickly pull the coil from the electrolysis cell, blow off the electrolyte, and quench in liquid nitrogen.
5. Quickly transfer to a pre-cooled stainless steel pressure vessel that is sitting in liquid N2 and pressurize with D2 to about 10 MPa (1450 psi).

This is based on my believe that electrolytic charging is more effective than charging under pressure. If this does not produce a superconducting state, then it might be possible to do this with plasma discharge:

6. Configure a concentric molybdenum-foil anode in the cyrostat. After step 5 above, with the Pd-D coil at liquid nitrogen temperature, reduce the pressure to about somewhere between 1 Torr (1/760 atmosphere) and one atmosphere and initiate a glow discharge, with the PD-D coil as the cathode (negative electrode). Hopefully this will further increase the D content.

DC glow discharges are possible at atmospheric pressure and very low power, with bulk plasma temperatures near room temperature, provided the electrical supply is modified to prevent the instabilities that lead to arcing.
"Low-temperature direct current glow discharges at atmospheric pressure, "Yixiang Duan; Chun Huang; Qingsong Yu, IEEE Transactions on Plasma Science (Volume: 33, Issue: 2, Apr 2005)
http://ieeexplore.ieee.org/abstract/document/1420460/

Here is an example of claimed excess heating & nuclear products when charging a Pd cathode with deuterium via glow discharge:
Karabut, A.B., Y.R. Kucherov, and I.B. Savvatimova, Nuclear product ratio for glow discharge in deuterium. Phys. Lett. A, 1992. 170: p. 265
http://www.lenr-canr.org/acrobat/KarabutABnuclearpro.pdf

Nuclear product ratio for glow discharge in deuterium
A.B. Karabut, Ya.R. Kucherov and I.B. Savvatimova
Scientific Industrial Association LUTCH, 24 Zhelesnodoroznaja Street, 142100 Podolsk, Moscow Region, Russian Federation
Received 24 September 1992; accepted for publication 28 September 1992 Communicated by J.P. Vigier

"New results for glow discharge in deuterium calorimetry are presented. In separate experiments a heat output five times exceeding the input electric power was observed. The result for the charged particle spectrum measurement is presented. Charged particles with energies up to 18 MeV and an average energy of 2-4 MeV were seen. Beams of gamma-rays with energies of about 200 keV and a characteristic X-ray radiation were registered. The summed energy of the registered. . The summed energy of the registered products is three orders short of the values needed to explain the calorimetric results.

Karabut continued to publish this method, including, most recently, 2012:
http://lenr-canr.org/acrobat/BiberianJPjcondensede.pdf#page=226

- - -
However, from 2005-2007, a group at Coolescence LLT, Boulder Colorado, headed by Rick Cantwell, failed to reproduce Karabut's results:
(Summary) http://www.coolescence.com/2005-2007-search-for-excess-heat-in-glow-discharge.html
Power points:
http://www.coolescence.com/uploads/9/1/1/5/91152790/2007_lanr_colloquium_presentation_.ppt
http://www.coolescence.com/uploads/9/1/1/5/91152790/2008_update_on_gd_experiment.ppt

The initial replication undertaken by the newly organized Coolescence team was the search for excess heat from palladium loaded with deuterium in a glow discharge. Excess heat had been first been reported from deuterium glow discharge onto a palladium target by Karabut's group in Russia. [1] About a decade later it was again reported in an early publication from the Energetics Technologies team in Israel. [2]

Following the lead of both earlier groups, a water cooled plasma chamber was configured as flow calorimeter. The initial calorimeter had a sensitivity of > 50 mW and an uncertainty > 2% of input power. Fast capacitive manometer type pressure gauges allowed for accurate flux and loading efficiency measurements using a pulsed plasma technique.

A second generation flow calorimeter was built with a sensitivity of 20 mW or 1% of input power. Loading behavior of Pd has been characterized in DC and pulsed DC discharges.

The following observations have been made during glow discharge loading runs:
No high loading (D/Pd < .7)
No bulk loading at higher temperatures (T > 80 deg C)
Loading rate proportional to current (J < 100mA/cm2)
5-10 D's loaded for each D+ of ion current (Faradaic Efficiency 5-10)
High D flux during pulsed discharge (.01 sccm/cm2 per mA of glow)
Instantaneous loading rate insensitive to temperature, voltage, and pressure
Glow discharge causes damage to Pd (sputtering)
No excess heat has been observed during glow discharge experiments.

[1] Karabut, A.B., Kucherov, Y.R., Savvatimova, I.B., Possible Nuclear Reactions Mechanisms at Glow Discharge in Deuterium, "Frontiers of Cold Fusion". 1992 Nagoya Japan: Universal Academy Press Inc., Tokyo, Japan
[2] Dardik, I, et.al, Intensification Of Low Energy Nuclear Reactions Using Superwave Excitation, in Tenth International Conference on Cold Fusion, 2003, Cambridge, MA USA

- - -
The loading rate was measured by the pressure drop and verified by unloading after the experiment. The Pd cathodes used were of two types: thin foil diffusion-bonded to a copper water-cooled cathode, and very thin Pd sputtered onto the cathode. Glow discharge caused distortion and damage to the cathode (sputtering).

- - -
(Reference 2 above, which Cantwell et al failed to replicate)

Intensification Of Low Energy Nuclear Reactions Using Superwave Excitation
I. Dardik, H. Branover, A. El-Boher, D. Gazit, E. Golbreich, E. Greenspan#, A. Kapusta, B. Khachatorov, V. Krakov, S. Lesin, B. Michailovitch, G. Shani# And T. Zilov
Energetics Technologies
Postbox 3026
Omer Industrial Park
Omer, Israel
E-mail: lesin@energetics.il.co
http://lenr-canr.org/acrobat/DardikIintensific.pdf

Dardik, I., Branover, H., El-Boher, A., Gazit, D., Golbreich, E., Greenspan, E., Kapusta, A., Khachatorov, B., Krakov, V., Lesin, S., Michailovitch, B., Shani, G., Zilov, T. Intensification Of Low Energy Nuclear Reactions
Using Superwave Excitation. in Tenth International Conference on Cold Fusion. 2003. Cambridge, MA: LENRCANR.org.
This paper was presented at the 10th International Conference on Cold Fusion. It may be different from
the version published by World Scientific, Inc (2003) in the official Proceedings of the conference.

3 Glow Discharge Cells
"The general layout of the GD cell designed at ET is shown in Figure 2 while a photograph of the cell is shown in Figure 3. The GD cell is made of a stainless steel cylinder. The inner surface of the stainless steel cylinder is coated with palladium using vapor deposition. In several cells a cylindrical Pd foil is inserted into the cell instead of the Pd coated film. The Pd surface constitutes one electrode, and a wire in the center of the cell constitutes the other electrode. The central wire is made of thoriated tungsten. Deuterium gas fills the volume of the cylinder. The pressure of the deuterium gas is in the range 5 to 100 torr before the initiation of the glow discharge. The body of the cylinder is constructed such that cooling water would extract the heat input to the glow discharge along with any amount of excess heat generated by LENR.

"A positive voltage between 300 and 1000 volts is applied to the central wire while the GD cell outer cylinder is maintained at ground potential. The small amount of thorium included in the central wire electrode is slightly radioactive, thus facilitating the establishment of the discharge throughout the gas volume. The ions created are forced by the electric potential towards the cell outer cylindrical wall and impinge upon the Pd target with a relatively high kinetic energy.

My notes:
The PD was vapor-deposited on the inside surface of the stainless-steel tube. After becoming deuterated, hit tended to flake off the tube.

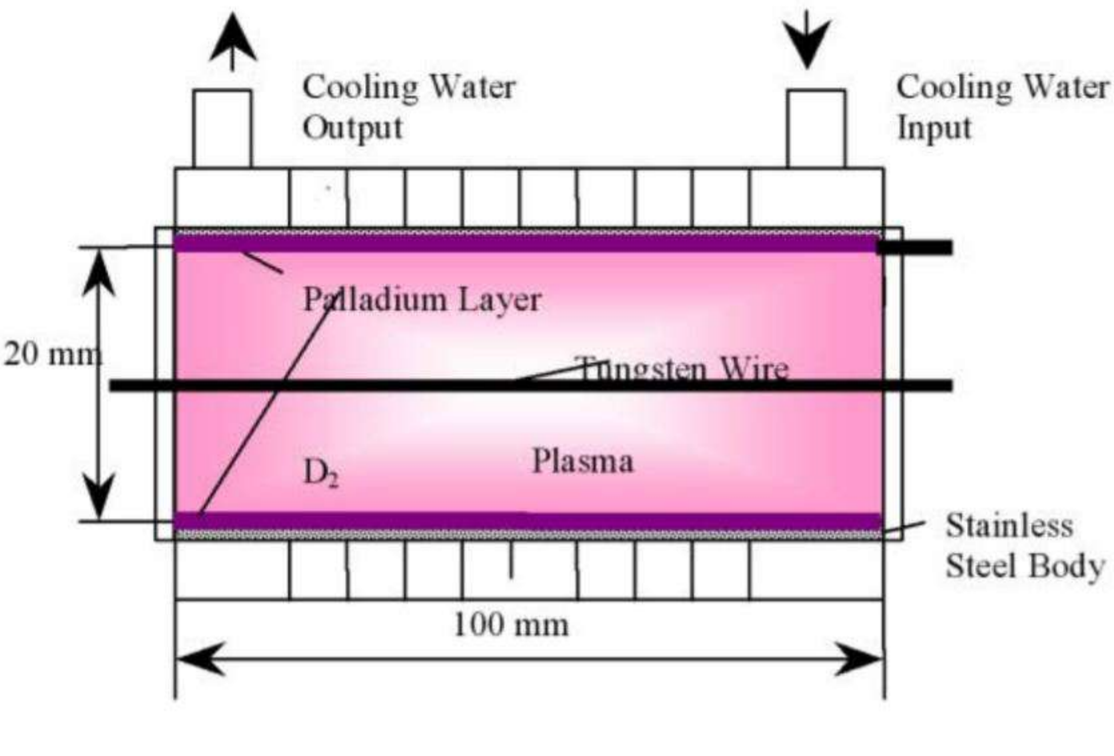

Figure 2 A simplified cross section of the glow-discharge cell

Figure 3 A view of the glow-discharge cell. The channels between the spiraling fins are for coolant flow

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I have searched for any attempts to charge Pd with H or D via glow discharge at low (liquid nitrogen) temperature and have not found any. This might be a crucial improvement.

Searches:

1. Google: ["liquid nitrogen" "glow discharge" deuterium hydrogen palladium] found none. aHan S. Uhm, Woodrow W. Lee, US Patent 5949835 A, do mention using liquid nitrogen as a coolant in ion implantation of D2 into palladium. This does not appear to anticipate preservation of any superconducting phase, but just to keep the target from overheating under very high ion flux, so as not to lose deuterium .
   http://www.google.sr/patents/US5949835
2. Ed Storms reviewed the field of "cold fusion" in 2003, updated in 2012, with a bibliography of 338 articles, nine of which employed glow discharge. Six of these are from Karabut et. al.
   http://lenr-canr.org/acrobat/StormsEastudentsg.pdf
3. A search of the library of full-text articles for "glow discharge" at lenr-canr.org finds about 50 articles, including those referenced by Storms. I could find none attempting low-temperature charging. A search of the entire library for "liquid nitrogen" returns only one pressure-charging experiment on Ti powder, cycled between room temperature and LN temperature.
   One novel calorimetric method involved exploding deuterated Pd wires in liquid nitrogen, using the heat of vaporization of LN as a calorimeter. This paper also reviews the group's experience in how to best replicate the Fleischmann-Pons effect, and how to stabilize Pd-D wires against loss of D by co-deposition of a little mercury on the surface.
   McKubre, M.C.H., et al., Calorimetric Studies of the Destructive Stimulation of Palladium and Nickel Fine Wires. J. Condensed Matter Nucl. Sci., 2014. 13.
   http://lenr-canr.org/acrobat/McKubreMCHcalorimetra.pdf

It will be necessary to provide efficient cooling of the PD coil, to remove the heat of the glow discharge and to prevent the superconducting phase from annealing out. How can this be done while also keeping the coil electrically insulated from the cooling surface? The difference in coefficient of thermal expansion of the different materials must also be overcome.

(If, in fact the Pd goes superconducting, it need not be electrically insulated from even a copper cooling surface, because, compared to zero resistance, even copper will appear as an insulator. This is the principle upon which superconducting magnet wire is made, by embedding filaments of Niobium in copper, drawing, and twisting it. If the Niobium component should go normal, the copper will carry the current during the quenching of the magnet.)

Here is an excellent review of the history and current state of Low Energy Nuclear Reactions:
Nagel, D.J., Evidence of Operability and Utility from Low Energy Nuclear Reaction Experiments. 2017, NUCAT Energy LLC. http://lenr-canr.org/acrobat/NagelDJevidenceof.pdf
(14 Aug 2017)
- - -
Although I do not fully understand him, I think that Peter Hagelstein has the best models(s) for the Fleischmann-Pons effect and has made a good effort of explaining a number of other experimental results.
P.L. Hagelstein / Journal of Condensed Matter Nuclear Science 19 (2016) 98–109
http://lenr-canr.org/acrobat/BiberianJPjcondensedr.pdf#page=191

Research Article
Current Status of the Theory and Modeling Effort based
on Fractionation
Peter L. Hagelstein∗
Massachusetts Institute of Technology, Cambridge, MA, USA

He believes that mono-vacancies are important for the effect, but that produced Helium-4 fills them and blocks further reaction. Thus higher temperatures should be useful, and perhaps especially use of nanometer-sized powders.
- - -
RF oscillations in the cathode current have been observed during production of excess heat in a Fleischmann-Pons setup.
Violante, V., et al., RF detection and anomalous heat production during electrochemical loading of deuterium in palladium, in EAI - Energia, Ambiente e Innovazione. 2014, ENEA.
Vittorio Violante, Emanuele Castagna, Stefano Lecci, Guglielmo Pagano, Mirko Sansovini, Francesca Sarto
http://lenr-canr.org/acrobat/ViolanteVrfdetectio.pdf
"The structures of the electrochemical interface during the
excess event and in the absence of excess power are compared, revealing a resonant equivalent circuit when the electrode is active. RF signals have also been detected when the anomalous heat production takes place

This has relevance to my early thoughts: May 6, 2017, "There may be a resonant frequency at which the protons and cooper-pair electrons in the hydrogen-filled superconductor need to be driven: it might be in the GHz range." 2 [note added 2017-10-09: Frequencies in the range of 20 to 38 THz will be needed to directly stimulate the phonon spectrum in Pd-H]15
- - -
This article also seemed to make sense to me: a deuteron approaches a heavy-metal nucleus with its neutron heading in first, gives up its neutron to the nucleus, and the resulting proton then recoils. Some experimental observations show changes in isotope compositions in support of this.
Passell, T.O., The Case for Deuteron Stripping with Metal Nuclei as the Source of the Fleischmann-

Pons Excess Heat Effect. J. Condensed Matter Nucl. Sci., 2015. 15.
http://lenr-canr.org/acrobat/BiberianJPjcondensedn.pdf#page=295
The Case for Deuteron Stripping with Metal Nuclei as the Source of the Fleischmann–Pons Excess Heat Effect, Thomas O. Passell, TOP Consulting, P.O. Box 336, Palo Alto, CA 94302-0336, USA
- - -
Well, that's an entire day spent catching up on the subject. I've seen some evidence to support my ideas, but I have yet much thought to put into it.
[signed] Wed 6 Sep 2016, 8:53 pm
= = =
2017-09-19 6:43 am
I awakened at 3:30 and took a sleeping pill (Trazodone) in an effort to get back to sleep. But I started thinking about "cold fusion" and finally got up, dressed, and ate some breakfast.

I thought a lot about stripping of alpha particles from heavy-metal nuclei with deuterium, or by pairs of hydrogen atoms, combined with weak-effect mediated conversion of hydrogen to neutrons, but I still don't know whether to favor this or simple d-d or h+h+h+h fusion.

The thermal effects seen might be due to collapse of local superconducting loops: quenching a superconductor converts all its electro-magnetic energy to heat. Since low-temperature superconductivity in Pd-D at 52-61 K3 seems to be driven by dislocation cores and expansion of the lattice, to allow partial filling of tetrahedral sites, it may be possible to enhance this by periodic stretching.

Experiment 2: Mechanically oscillate the Pd-D lattice

1. Make the spool in experiment 1 6 out of longitudinally-placed wedges of a piezoelectric material, such as quartz or another high-temperature piezoelectric material, such as http://www.trstechnologies.com/Materials/High-Temperature-Piezoelectric-Ceramics

2. Orient the wedges so that the expansion under application of electric field is normal to the surface of the wedge, that is tangent to the circumference of the cylinder.

3. Machine a spiral slot on the circumference for the "wire."

4. Evaporate or sputter a very thin film of Pd (or Ni or other material to be tested) onto the circumference of the cylinder, then machine, scrape, or grind the material off the ridges so that the wire is not short-circuited. In practice, the thickness of an evaporated or sputtered film is often monitored by its effect on the resonant frequency of a quartz crystal as it gains mass. This could be used to control the thickness of the wire. It should be made as thin as possible, consistent with electrical continuity.

5. The coil will have a mechanical resonant frequency. Tune the electrical circuit by changing the parallel capacitance to the same frequency.

6. This will add high frequency compression and expansion of the wire, while it is being charged with H or D and will hopefully drive it into at least periodic superconductivity and nuclear activity.

7. If this succeeds, this will also help establish whether the nuclear activity involves only creation of helium-4, or whether spallation of alpha particles off metal nuclei is occurring: If the film is thin enough, any isotopic shifts can be analyzed, and eventually the active isotopes will be consumed. If H or D is the only source of He-4, then the reaction should continue as long as H or D is supplied.

[signed] Tuesday, 2017-09-19, 8:35 am
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2017-10-09 More reading about superconductivity in Pd-H & Pd-D and its relevance to fusion

I've been reading to learn more about superconductivity and its possible relation to "cold fusion." I followed up on reference 26 in the paper by H. M. Syed, et al 3: The role, if any, of dislocations in superconductivity in PdHx/Dx is not clear, although it has been proposed [26] that filamentary superconductivity may occur within dislocation cores."

Superconductivity in dislocation cores of PdH: A. Lipson, B. J. Heuser, C. Castano, G. Miley, B. Lyakhov, and A. Mitin, Phys. Rev. B 72, 212507 (2005).

Transport and magnetic anomalies below 70 K in a hydrogen-cycled Pd foil with a thermally grown oxide

http://positron.npre.illinois.edu/publications/2005-phys-rev-b-lipson-pd-sc.pdf

"In summary, we have observed anomalies in the electron transport and magnetic properties in a deformed Pd foil with a thermally-grown oxide layer and a small residual hydrogen concentration trapped at dislocations. The anomalies are consistent with a filamentary superconducting network that we attribute to the condensation of the trapped hydrogen into a metallic-like phase within the dislocation core. Dislocation pileup at the Pd-Pd oxide interface is thought to promote the filamentary nature of the network. This phase represents a hydrogen dominant metallic alloy, where both hydrogen and palladium atoms may participate in common overlapping bands. Finally, we note that the presence of nonstoichiometric oxygen near the Pd-oxide layer interface may enhance electron-phonon coupling and therefore increase the critical temperature, similar to the cuprates."

They took a thin (12.5 micrometer) cold-rolled Pd foil and grew a 20nm thick oxide layer on both sides by heating it in an oxygen-propane flame at 1200 °C for 6 s. "The sample was then cathodically loaded with hydrogen to PdH0.7 at a current density of 5.0 mA/cm2 in a 1 M Li2SO4 /H2O #99.99% pure electrolyte. Hydrogen was removed from the sample by reversing the current, resulting in one hydrogen loading-unloading cycle. The sample used here was cycled five times."

"The sample was finally annealed at 300 °C in vacuum of 10−7 Torr for 2 h to remove all but the strongest bound hydrogen." Thermal desorption measurements then showed a peak at about 400 C, as the most strongly-bound hydrogen (from dislocations cores) was finally released. Bulk superconductivity was not observed, but a variety of measurements indicated the possibility of a superconducting phase at temperatures below 67 K. (Boiling point of nitrogen is 77K).

This report does not discuss possible relevance of this observation to "cold fusion," but Miley explicitly discusses it in this publication:

Fusion in PdD in dislocation cores: Condensed Matter “Cluster” Reactions in LENRs

Miley, G.H., H. Hora, and X. Yang. Condensed Matter "Cluster" Reactions in LENRs. in ICCF-14 International Conference on Condensed Matter Nuclear Science. 2008. Washington, DC.

http://www.lenr-canr.org/acrobat/MileyGHcondensedm.pdf

"In this paper we first point out evidence for condensed matter cluster formation based on thin-film electrolysis. Next, measurements of superconductivity in condensed matter deuterium “clusters” in dislocation sites loaded-deloaded palladium thin films are briefly reviewed, followed by a discussion of techniques under study to increase the number of such sites per unit volume of the electrodes. Estimates for resulting “cluster reaction” rates – flow enhanced Pycnonuclear fusion are given. If successful, this approach offers a “Road map” for future power unit based on thin films and clusters."

Miley calls the multiply-charged & discharged oxidized Pd films “Dislocation Loops by Repetitive Loading-Deloading (DLRLD) electrodes”

He's also experimented with electroless deposition of PD on nickel felt and nickel foam, giving very large surface areas and very thin coatings, about 50 nm. "Some preliminary electrolytic studies have been encouraging, but much more needs to be studied to understand the true promise of this new electrode design."

"An estimate of Cluster fusion rates in such dislocation loops at high D density follow from the well known Pycnonuclear reaction theory used for calculation of high density state fusion in astrophysics [6]. (S.L. Shapiro and S. A. Teukolsky, “Polynuclear Reactions.” Black Holes, White Dwarfs, and Neutron Stars. New York: John Wiley & Sons. 72-81, (1983).)
An accessible paper depicting this theory, with application to hot and cold fusion, is:
"Pycnonuclear reaction and possible chain reactions in an ultra-dense DT plasma," S. Son ∗
, N.J. Fisch, Physics Letters A 337 (2005) 397–407
http://w3.pppl.gov/~fisch/fischpapers/Son_Chain_react.pdf
Basically, at densities exceeding that of ordinary stars, but perhaps seen in the crust of neutron stars, the wave functions of nuclei are forced to overlap, and fusion occurs. The light elements exist in a lattice, and so solid-state theory applies to the process.

Miley suggests that densities suitable for Pycnonuclear reactions is approached in the dislocation loops in Pd.

Here is a slide presentation illustrating Pycnonuclear reaction theory, with its history: Pycnonuclear Reactions," by D.G. Yakovlev, A.I. Chugunov, L. Gasques, O.Y. Gnedin, P. Haensel, K.P. Levenfish, M. Wiescher
http://www.uni-mainz.de/FB/Chemie/AK-Noertershaeuser/workshop/files/talks/yakovlev_Almas.pdf

"The reaction rate increases exponentially with growing density" and will even occur at very low temperatures approaching 0K."

A U.S. patent has been issued to Miley for the multiply-cycled oxidized PD foil electrode: Dislocation site formation techniques, US8227020 B1, 24 July 2012, George H. Miley, assigned to Npl Associates, Inc https://www.google.com/patents/US8227020

In the 2011 LENR conference, Miley presented "A Revolutionary Radioisotope Thermoelectric Generator (RTG) Based on Low Energy Nuclear Reactions (LENRs)", George H. Miley, Xiaoling. Yang1 Heinrich Hora. Here are the slides:
http://newenergytimes.com/v2/conferences/2011/WGES/WGES-Miley.pdf

He presents work on thin film Pd/Ni cathodes on a glass or quartz substrate, motivated by "Swimming Electron Layer (SEL)" theory, that "High density electron clouds – exists between metals of different Fermi energy, providing the necessary screening."
Using a 8000Å Pd on top of 1000Å Ni on Alumina as a cathode, they measured, in 18 runs, three runs that gave excess heat, the highest being a factor of 4 times input energy. With CR-39 foils "MeV charged-particles are detected: Alpha-Particles and Protons"

He referenced the above work with dislocation loops at the interface between PdO and Pd, and cited recent greatly-improved hydrogen densities in the dislocations, measured again by Thermal desorption experiments, but didn't show any attempt to obtain excess heat using this as a cathode.

However, they did use these clusters as a target at LANL, using the TRIDENT petawatt laser, and did see acceleration from clusters.

Citation for the SEL theory: Yeong E. Kim, "Theory of Bose–Einstein condensation mechanism for deuteron-induced nuclear reactions in micro/nano-scale metal grains and particles, Naturwissenschaften, 96(7):803-11 (2009)"
https://www.physics.purdue.edu/people/faculty/publications/yekim/naturwis-printed-pub.pdf

"Theory is based on the concept of nuclear Bose–Einstein condensate state for mobile deuterons trapped in a micro/nano-scale metal grain or particle, which acts as a confinement or trapping potential, similar to a magnetic trap used to observe the atomic BEC phenomenon with atoms."

There is no mention of a "Swimming electron layer;" perhaps this term was coined by Miley.

More recently, Miley is loading "High purity (99.999%) D2 gas at 4 atm with a nano powder of 20g ZrO2Pd35 at room temperate." He reports more than twice the heat released that could be expected from chemical absorption: 1749 J vs 690 J expected, reporting 350 W/kg.

The Q&A session following this presentation is available in a 23-minute YouTube video, dated Oct 25, 2011, in which George Miley discusses the status, to date, of his work: "Questions for Peter Hagelstein and George Miley talk" https://www.youtube.com/watch?v=N1m2wQevFAY
Miley's portion begins at 5:27. He's focusing on generating heat at a high enough temperature to run a Radioisotope Thermoelectric Generator" (RTG) similar to that used in space probes, that have been powered by heat from Plutonium-239. At 23:04 he discusses the D2 gas loading experiment. The reaction is triggered by changing the pressure. At 17:56 he states, "At the moment, we can run continuously at levels of a few hundred watts. We'd like to go to about 300 watts." He speaks about commercializing this.
- - -

Second thoughts on driving the PdD at some "resonant frequency"

With reference to my brief speculation on May 6, 2017, "There may be a resonant frequency at which the protons and cooper-pair electrons in the hydrogen-filled superconductor need to be driven: it might be in the GHz range 2 , I've been reviewing solid-state theory. Any solid with more than two atoms within the unit cell has two bands of allowed vibrational modes: the acoustic mode, wherein atoms move in phase with each other, and the optical mode, wherein they move out of phase with each other.

The optical phonon spectrum in Pd-H ranges from about 650 cm^{-1} (19.5 THz) to about 1250 cm^{-1} (37.5 THz)

A calculation of the band spectra for PtH & PdH is found in "Anharmonic free energies and phonon dispersions from the stochastic self-consistent harmonic approximation: application to platinum and palladium hydrides," Ion Errea, Matteo Calandra, Francesco Mauri, Submitted on 13 Nov 2013 Physical Review B 89 (6), 064302, https://arxiv.org/abs/1311.3083

They use a stochastic (random input) method to converge an otherwise very difficult problem, concluding, " The validity of the method is demonstrated in the strongly anharmonic palladium and platinum hydrides. In both cases we predict a strong anharmonic correction to the harmonic phonon spectra, far beyond the perturbative limit. In palladium hydrides we calculate thermodynamic properties beyond the quasiharmonic approximation, while in PtH we demonstrate that the high superconducting critical temperatures at 100 GPa predicted in previous calculations based on the harmonic approximation are strongly suppressed when anharmonic effects are included."

The calculations are presented graphically on the following page: The blue line, for step "F," represents the end result.

"FIG. 2. (Color online) The evolution of the SSCHA calculation in PtH at 0 K and 100 GPa. The starting Hamiltonian is the harmonic one . . .
In (a) we depict the [calculation details not of interest to me].
In (b) the evolution of the phonon spectra is plotted presenting the results at iterations B, D, and F, together with the starting harmonic phonon spectra." (Use the blue line, F, the final result)

Using the blue lines, we see that the allowed acoustic frequencies range from zero cm^-1 (0 Hz) to about 300 cm^-1 (9.0 E12 = **9.0 THz**), and the allowed optical frequencies range from about 650 cm^-1 (**19.5 THz**) to about 1250 cm^-1 **(37.5 THz**).
(Conversion of wavenumber to frequency of electromagnetic radiation: In optical spectroscopy, the wave number, the reciprocal of the wavelength, is usually used in preference to the wavelength. The symbol for wavenumber is ν-bar (ν with a bar over it), pronounced nu-bar. The symbol for wavelength is λ, lambda. Thus ν-bar = 1/ λ. Speed = wavelength * frequency, thus, for light, c=λν, λ=c/ν or λ=c*ν-bar, where c is the speed of light in a vacuum = 3.00 x 10^10 cm/sec).

The optical phonon frequency range from about 20 THz to about 38 THz is in the range of infrared light, which covers the range from about 300 GHz to 400 THz. (http://www.davidterr.com/science-articles/electromagnetic_spectrum.html) The highest-frequency obtainable by a solid-state electronic device is a GaN HEMT (high electron mobility [field-effect] transistor) operating at about 400 GHz. http://ieeexplore.ieee.org/document/7838337/

It seems likely that if fusion involves superconductivity, optical phonons must be involved, as only they produce a dipole moment that will move protons/deuterons and electrons in opposite directions. Direct stimulation of these phonons will require frequencies about a million times the GHz range about which I had speculated!

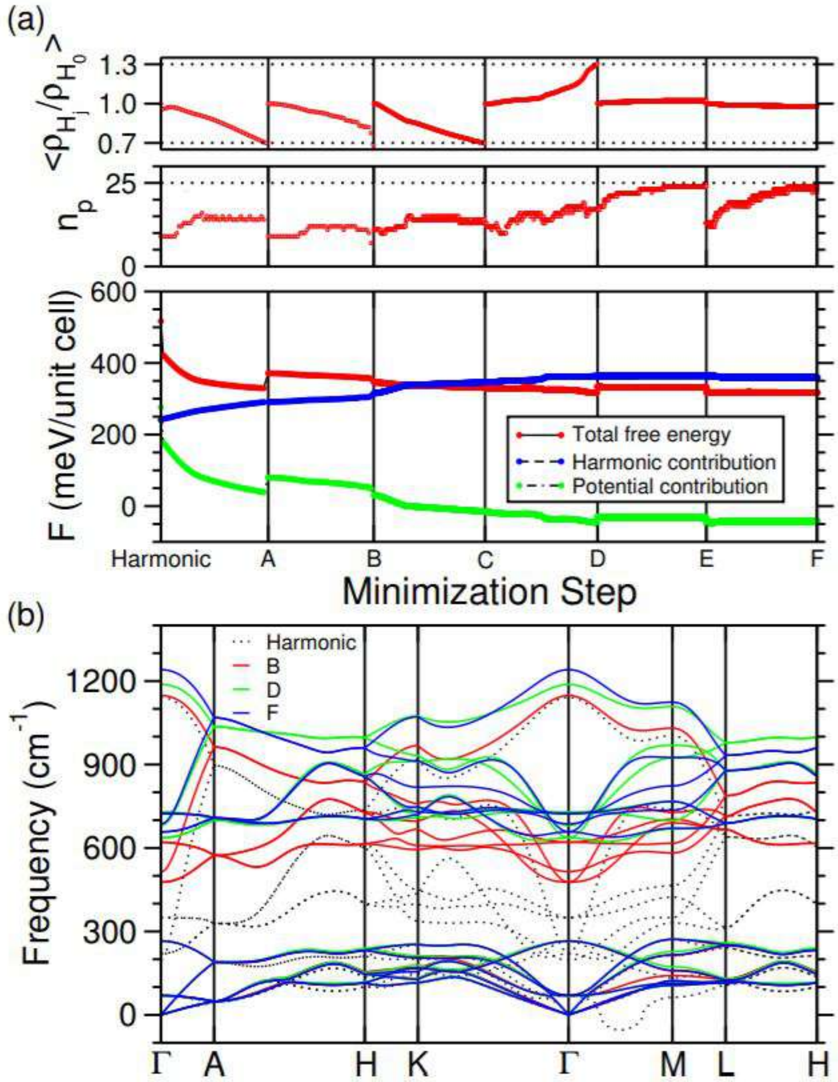
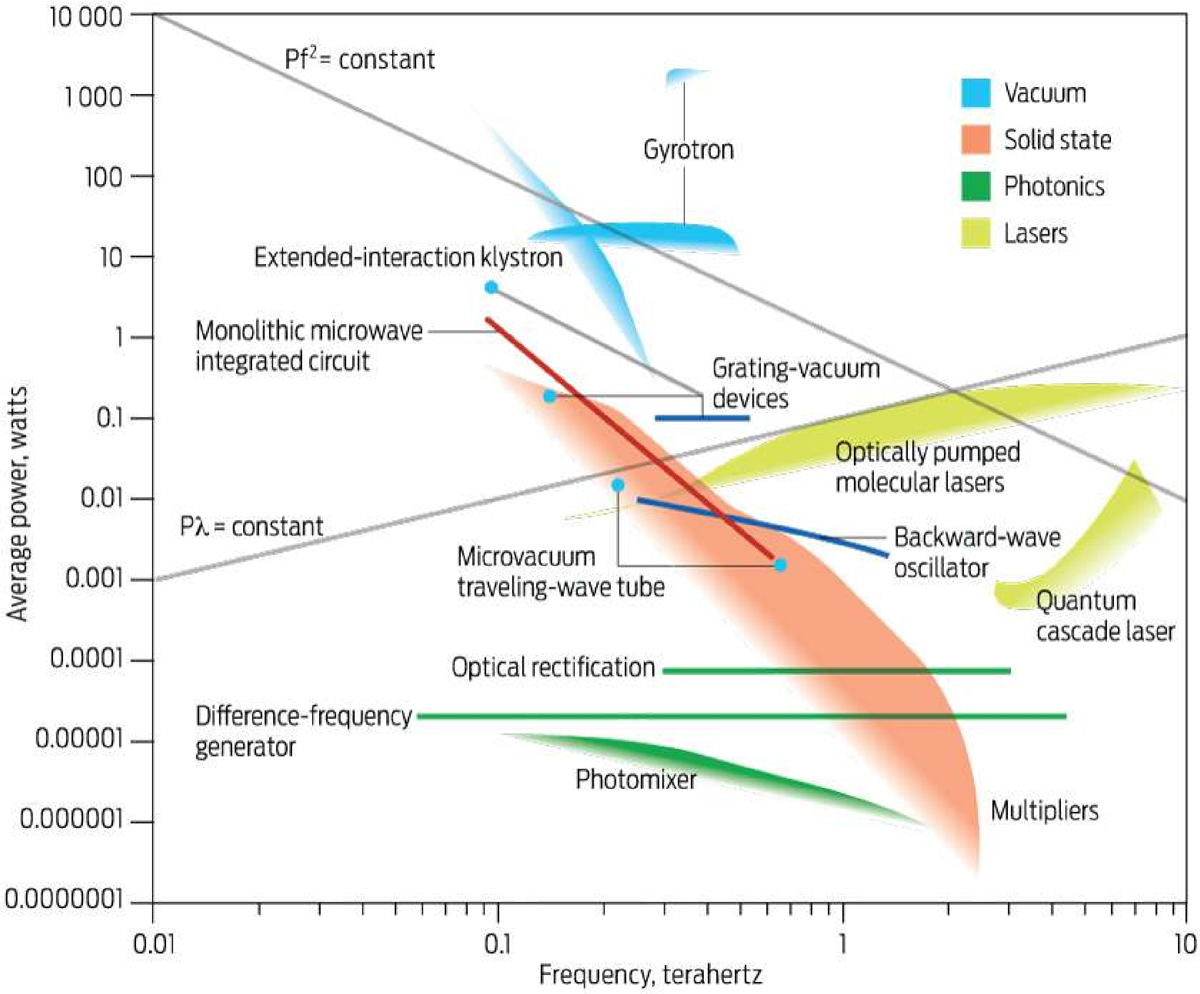


Figure 2, page 10 (caption above).

"The Truth about Terahertz," Carter C. Armstrong, IEEE Spectrum, 17 Aug 2012, https://spectrum.ieee.org/aerospace/military/the-truth-about-terahertz
reviews the state of the art. As a communication medium, it's severely limited by absorption in atmosphere: a "terahertz wall" prevents sending a signal more than about 100 meters. Generators of THz radiation are available, up to about 8 THz, but are generally less than 1% efficient. The illustration on the next page summarizes the field: (Illustration: George Retseck)



It looks like an optically pumped molecular laser is the device most closely approaching the range for direct stimulation of optical phonons in PdD, but it would have to produce a hundred-to-thousand-fold output in energy to justify its own energy cost, and it's not exactly a miniature, portable device. Quantum cascade lasers, while miniature, must be cooled to very low temperatures, also an undesirable feature, and they are presently just in the experimental phase, requiring extremely precise control of molecular beam epitaxy.

Based on all the experimental evidence, some form of stimulation of electron and deuteron currents is needed, but clearly bulk stimulation at resonant frequency of the optical phonons is beyond reach.

There are, of course, semiconductor lasers for the infrared region. They are usual specified in wavelengths of nm. To convert n-bar, in reciprocal centimeters, to lamda, in nm:
1 cm/nu-bar * m/100 cm * 10^9 nm/m: wavelength, in nm = 10^7 / nu-bar. Our range of 650 cm-1 to about 1250 cm-1 is thus from 10^7/650 to 10^7/1250 or from 8,000 nm to 15,500 nm, or in micrometers (microns): from about 8 microns to 16 microns.

Here is a provider of semiconductor lasers from wavelengths from 375 nm to 11,000 nm (11 microns): Thor Labs: https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=9129

[signed HTHallJr, Mon 9 Oct 2017, 9:30 pm]
- - -

2017-10-10 More reading on solid-state band theory for both phonons and electrons and trying to better understand superconductivity.

7:00 am: I should have known, just from their names, that the acoustic band is in the 0 to MHz range of frequencies, and that the optical band is in the infrared range. Perhaps by reading how these bands are measured will help me to better understand how to stimulate activity in each region.

This is an excellent tutorial in elementary solid state quantum physics, "All About Circuits," by Tony R. Kuphaldt:
https://www.allaboutcircuits.com/textbook/semiconductors/chpt-2/quantum-physics/

I immediately liked the way he used simple analogies, such as moving from one seat to another in an auditorium, so I googled his name to learn more about him:
"Tony R. Kuphaldt is an instructor at Bellingham Technical College in Bellingham, Washington. He has taught instrumentation technology for five years at that institution, and is currently on leave to further his own education. Becoming a full-time student once more has been an enlightening experience for him and has served to reinforce his conviction that "learning to learn" is the most important goal of education," an introduction from an essay that he wrote in the winter 2004 issue of the NEA Higher Education Journal:
http://www.nea.org/assets/img/PubThoughtAndAction/TAA_04Win_05.pdf
See also his "manifesto," which appears to be the same document:
http://www.ibiblio.org/kuphaldt/socratic/doc/lett0045.pdf

"Dispense direct instructor-to-student transmission of knowledge like a doctor would prescribe cortisone: with caution, knowing that it is highly effective for specific problems in the short term, but crippling if used over an extended period of time." (Note: the link at the end of the NEAHEJ essay has changed: it is now http://www.ibiblio.org/kuphaldt/socratic/

Signed 27-10-10 7:20 am.
- - -
Thursday 12 Oct 2017
10:09 am I've been thinking a lot about superconductivity in PdD of Syed et al 3 and the speculation of Miley et al 13 that it is associated with dislocation loops, and that these dislocations are stabilized at a junction between dissimilar metals or between PdD and an oxide. If dislocation cores are indeed crucial, then it is necessary not only to crate and stabilize these cores, but to connect them electrically to each other to allow the fusion energy to be dissipated as electrical current rather than as heat. High-temperature superconductors like bismuth strontium calcium copper oxide (BSCCO, pronounced "bisko") are ceramics with a very weak graphite-like plane through which the superconducting current flows.
https://en.wikipedia.org/wiki/Bismuth_strontium_calcium_copper_oxide

Individual crystals must be atomically aligned on these planes for a continuous current to flow. Fortunately, this occurs naturally when the crystals are sheared. The powder-in-tube (PIT) method accomplishes this goal: "Typically, precursor powders are packed into a silver tube, which is then extruded down in diameter. These are then repacked as multiple tubes in a silver tube and again extruded down in diameter, then drawn down further in size and rolled into a flat tape. The last step ensures grain alignment. The tapes are then reacted at high temperature to form dense, crystallographic ally aligned Bi-2223 multifilamentary conducting tape."
https://en.wikipedia.org/wiki/Bismuth_strontium_calcium_copper_oxide#Wires_and_tapes

Experiment 3: Powder-in-tube processing of PdD to create an electrically-connected network of superconducting dislocation cores.

PIT processing might succeed in developing an electrically continuous network of dislocation cores in PdD. Nanometer-sized particles of PdD would be mixed with an insulator (ZrO2 seems to be favored by a number of cold-fusion workers, including Miley.) Instead of a silver tube, a silver-palladium tube, which facilitates the transfer of hydrogen, might be used. Pd-Ag is ductile, as are a number of other solid-solution Pd alloys that have been investigated for purification of hydrogen: http://www.technology.matthey.com/pdf/3-12-pmr-jan11.pdf

1. The tube will first be packed with the highest possible density of the nanometer powders, then subjected to high vacuum and brazed or sealed to a ductile copper plug at each end to make the tube vacuum tight.

2. At this stage, and each subsequent stage, the tube is evacuated at elevated temperature (say 400 C) and re-infiltrated with D2, several times, to repeatedly pass the Pd through the 2-phase region, until its electrical resistivity settles toward a constant value.

3. It then cooled rapidly to liquid N2 temperature (or below, if necessary) to check for superconductivity.

4. As per Syed et al, the resistivity is monitored while rapidly warming to room temperature, taking no longer than about 30 minutes. Monitoring the resistivity at room temperature will also serve to characterize the electrical connectivity of the system.

5. After return to room temperature, the tube is pointed and drawn (pulled from the pointed end) through a die to the next-smaller possible diameter, to shear the contents longitudinally and enhance electrical connectivity. Pointing may be accomplished by pushing into a gently tapered die, or, perhaps by a rolling operation.

6. Repeat steps 2-5 until the wire reaches the smallest possible diameter, or until maximum superconducting temperature is reached and fusion is evidenced, either by heat production, or, ideally, by direct conversion to electrical energy.

After drawing, the wire should be inserted in a high-strength metal tube for vacuum processing, pressurization, cooling to low temperature, and electrical characterization, as per Syed et al. Maximum deuterium pressure is maintained during the cooling cycle and while warming to room temperature.

Experiment 4: Variation on Experiment 3 with impermeable high-pressure tube, drawing to obtain extreme pressures.

In this case, instead of drawing the powder in a relatively thin-walled Pd-alloy tube that is permeable to hydrogen at elevated temperature, it is contained in a thick-walled stainless steel tube that is capable of withstanding a pressure of perhaps 10,000 p.s.i. and is resistant to hydrogen embrittlement. (Embrittlement might be avoided by coating the inside diameter with a malleable, hydrogen-impermeable material such as copper.) It is evacuated once, at high temperature, then pressurized to maximum pressure & depressurized several times, to pass the PdD several times through the two-phase region, and finally permanently sealed at high pressure and temperature. The "thinned" 660 stainless steel pressure vessel used by Syed at all was 12.7 mm (½ inch) in diameter and had a pressure rating of 10 MPa (1450 PSI) at 300 C. Wall thickness was not specified.
Engineering toolbox gives a chart of temperature vs allowable stress for types 304, 316, and 321 stainless steel. Of those rated, not including 660, A312 TP321 has the best strength: 13,000 psi at

1000 F (540 C); type 304 is good at 13,000 psi to 850 F (450 C), and type 316 is good to 12,000 psi at 850 F (450 C)
http://www.engineeringtoolbox.com/temperature-allowable-stresses-pipes-d_1338.html
Note that this is stress, not pressure of a contained gas.

For thin-walled tubes, with wall thickness less than 5% of the tube diameter, the hoop stress sigma-h = pressure * diameter / (2* thickness).
http://www.engineeringtoolbox.com/stress-thin-walled-tube-d_948.html

Swagelok gives the following pressure ratings for 304 or 316 stainless steel tubing, with a nominal tensile strength of 20ksi:
1/8 inch OD, .028" wall: 8,500 psi.
¼ inch OD, .035: wall: 5,100 psi; .049" wall: 7,500 psi; .065" wall: 10,200 psi.
1/16 inch OD, .014: wall: 8,100 psi; .020" wall: 12,000 psi.
Temperature de-rating: 200F 93C: 1.0; 400F/204C: 0.96; 600F/315D: 0.85; 800F/426C: .79; 1000F/537C: 0.76.
https://www.swagelok.com/downloads/webcatalogs/EN/MS-01-181.PDF, page 190-191

In this case, each drawing to a smaller diameter will retain the internal high pressure. As subsequent drawing operations distort the powder, its porosity will decrease, the total volume of solid will decrease, and the gas pressure in the pores will increase. The pressure capacity of a pressure vessel basically depends on the ratio of the ID to the OD:

signed 11 Oct 2017, 4:17 pm
- - -
2018-03-08 2:01 pm
(shared earlier in the day to Facebook)
From my reading this morning in the Book of Mormon:
"Treasures in Heaven" is an ancient Jewish teaching!
Special bonus: an ancient Jewish queen wrote a portion of the Torah on a gold plate!
I was reading the denunciation by Nephi II, son of Helaman II, of the corrupt rulers of Zarahemla:
"Behold, ye have rejected the truth, and rebelled against your holy God; and even at this time, instead of laying up for yourselves treasures in heaven, where nothing doth corrupt, and where nothing can come which is unclean, ye are heaping up for yourselves wrath against the day of judgment."
(Helaman 8:25) http://bit.ly/2FBHrik
Although Nephi II spoke these words about 22 years before the birth of Christ, they are strikingly similar to the teaching of Jesus, in the Sermon on the mount, given some 50 years later and halfway around the world. And Jesus repeated these teachings to the Nephites in person, after his resurrection.
(Matthew 6:19-20, 3 Nephi 13:19-2) http://bit.ly/2FiRXf8, http://bit.ly/2DbC44c
In the next moment Nephi declared, by revelation, the murder of the chief judge and the identity of the murderer. So Nephi may have received "treasures in heaven" by direct revelation. Often, however, pondering upon scripture is a catalyst for revelation, and I'm sure that Nephi had often pondered the writings on the Brass Plates, the "record of the Jews" which Nephi I had brought from Jerusalem about 600 BCE.
Moreover, Helaman II had earlier taught these same words to his sons Nephi II and Lehi II, with reference to their namesakes, Nephi I and Lehi I:
"Therefore, my sons, I would that ye should do that which is good, that it may be said of you, and also written, even as it has been said and written of them.
"And now my sons, behold I have somewhat more to desire of you, which desire is, that ye may not do these things that ye may boast, but that ye may do these things to lay up for yourselves a treasure

in heaven, yea, which is eternal, and which fadeth not away; yea, that ye may have that precious gift of eternal life, which we have reason to suppose hath been given to our fathers."
(Helaman 5:7-8) http://bit.ly/2FrvFUC
Note that "said and written," repeated twice, echoes the Jewish tradition of two Torahs, one oral and one written, implying that the Nephites, too, had both an oral and a written tradition. Although Helaman II and Nephi II do not state specifically that "treasures in heaven" came from the Brass Plates, Helaman's teaching in the context of their scriptures makes it very likely.
This led me to wonder if "treasures in heaven" is also found in ancient Jewish tradition. Indeed, it is!
Consider the wonderful story of King Monobaz, whose mother, Queen Helena, had converted, with her sons Monobaz and Izates, to Judaism. They reigned in Adiabene, the capital of a rich country which extended over a part of the former Assyrian empire, in the first decades of the common era.
https://www.chabad.org/library/article_cdo/aid/112276/jewish/Queen-Helena.htm
When Monobaz was criticized for squandering his money on the poor, both in his own state and in relief that he sent to to Jerusalem, he responded:
"My ancestors amassed treasures in this world, while I gather treasures for the world to come. My ancestors placed their treasures in chambers, and had to guard them against thieves; my treasures are far from the reach of any greedy hand, and will be safe forever. My ancestors' treasures did not produce any fruits, but mine continue to bring more and more fruit."
Sound familiar? (See also https://en.wikipedia.org/wiki/Monobaz_II)
The Jewish Encyclopedia gives a more detailed version and also references each of his statements with scripture: http://www.jewishencyclopedia.com/articles/1295-alms
"My ancestors laid up here on earth; I in heaven (Psalm 85:12) http://bit.ly/2oTGLLH
My ancestors laid up treasures where the human hand can reach them; I, where no human hand can reach them (Psalm 89:15) http://bit.ly/2G52RlT
My ancestors laid up treasures that bear no fruit; I, such as bear fruit (Isaiah 3:10)
http://bit.ly/2tthGfA
My ancestors laid up treasures of Mammon; I, treasures of souls (Proverbs 11:30)
http://bit.ly/2HiiXIk
My ancestors gathered and will not reap the benefit; I have gathered and shall reap the benefit (Deuteronomy 24:19-22) http://bit.ly/2IfnigD
My ancestors laid up treasures for this world; I, for the world to come, as it is said: 'Thy righteousness [almsgiving] shall go before thee and the glory of the Lord shall be thy rearward.'"
(Isaiah 58:8) http://bit.ly/2FBRYKo
Finally, a bonus I received while searching for commonality between the oral and written traditions of the Nephites and the Jews:
(Drum roll...) "Another gift of Queen Helena was a TABLET OF GOLD, on which she had a certain portion of the Torah inscribed, which was of special interest to women" (emphasis mine)
(Chabad, op cit. http://bit.ly/2G6a6Ki)
- - -
Friday 2022-02-04 8:02 a.m.
I recently became aware of the use of high-temperature superconductors in filters for cell phone relay stations. Something along these lines involving a resonant cavity might prove useful, if a thin layer of a hydrogen-absorbing metal is placed adjacent to the superconductor.
Example: https://xdevs.com/doc/STI/doc/simon2004.pdf
"Superconducting Microwave Filter Systems for Cellular Telephone Base Stations" Simon et. Al, Proceedings of the IEEE, V. 92, No. 10, October 2004.
signed 8:06 a.m.
- - -
Wednesday 2022-03-16 9:06 a.m.
I've been reading literature about super-high pressure synthesis of room temperature superconductors in diamond anvil cells. So far I've not seen any speculation about possible fusion in

superconducting deuterides. The DAC is a valuable tool for basic science but obviously has no commercial applicability.

This morning, however, I came across a recent theoretical paper by Pin-Wen Guana, Russell J. Hemley, and Venkatasubramanian Viswanathana, of Carnegie Mellon Institute in Pittsburgh (PWG & VV) and the University of Chicago (RJH) about combining electrochemical potential with moderate high pressures to create super-hydrides, which they call P^2 (for the combined effects of the two different potentials).

"Combining pressure and electrochemistry to synthesize superhydrides." Pin-Wen Guana, Russell J. Hemle , and Venkatasubramanian Viswanathana, PNAS 2021 Vol. 118 No. 46 e2110470118, Combining pressure and electrochemistry to synthesize superhydrides | PNAS

PWG & VV are at the Carnegie Mellon Institute in Pittsburgh; RJH is at the University of Chicago. Two of the authors, G & V, have applied for a patent for this idea.

The big advantage of combining the two potentials is that high pressure suppresses the evolution of hydrogen gas, which is a barrier to introducing protons into the bulk metal at the electrode surface. Their calculations do not take many real-world possibilities into effect, such as the known strong effects of crystalline impurities, dislocations, etc., but they are intriguing.

Without having the knowledge or tools to do such calculations, I have believed, for a long time, that doing electrochemistry in a Pd-D cell in the cubic high pressure press might greatly enhance the prospects of Fleischmann-Pons-type "cold fusion."

G, H, and V estimate that at a palladium superhydride, PdH_{10}, could be synthesized electrochemically at pressures above about 300 MPa, or 3 kbar. That's easily obtainable in the cubic press in a "bulk" size!

Signed 2022-03-16 9:25 am.
- - -

Friday April 29, 2022 7:52 a.m.
This morning I awakened at about 4 am, as I often do. After returning to bed, I prayed, as I have often done, that the Lord would reveal to me the secret to cold fusion, that I could be an instrument in his hands to give this gift to his children. In connection with that desire, I have determined that if I am blessed with that revelation, that I should give the gift anonymously and without compensation to all the world, in such a manner that it is a sign to the world of God's love for his children, and as a testament to the truth of the Restoration.

I then received an idea for a possible solution. I've believed for some time that the "Fleischmann-Pons" effect, which has proved nearly impossible to repeatably reproduce, arises from small regions of very high deuterium density that put the negative palladium-deuteride electrode into a superconducting state. I have also believed that if a microwave cavity lined with a superconducting deuteride alloy can be made superconducting, that spontaneous microwaves would arise as fusion occurred, so that the fusion energy would be directly convertible to electricity.

The idea is this: combine high gas pressure with electrolytic charging. Make a thin-walled microwave cavity of palladium, or perhaps of palladium-coated titanium, with ends of the same alloy, with an antenna configured at one end to extract the microwaves into a diode array. Surround the cavity with an absorbent material saturated with alkaline electrolyte, doped with lithium hydroxide, wrap around that a platinized titanium mesh for the anode, and seal this in a thin-walled stainless-steel tube. Provide the assembly with leads to provide electrolyzing current and contacts to measure the electrical resistivity of the cavity. Then place this in a strong stainless steel vessel capable of about 3,000 psi. Pressurize with deuterium, and after the cavity has absorbed as much D2 from pressure as possible, super-charge it with Deuterium via electrolysis.

- - -
*****
Recalling the providential events of May 5, 2022, when my brother David and I decided to return to cold fusion research!
Friday, May 13, 2022, visiting Joshua & Roxanne Merrill & family in Albuquerque, New Mexico. Their daughter Morgan Johanna graduated yesterday from Southwest High School, and Joshua receives his Master's degree tomorrow from University of New Mexico.

On Wednesday May 4, 2022, at 9:13 pm, I received the following text message from my granddaughter Hazel Wheeler, 13, who is the youngest child of Zina Hall and Dean Wheeler (phone # 801-361-3983):
"Hello, this is Hazel and I have to do an assignment for history where I interview somebody who has experienced one or more major historical events firsthand and compose an oral history from it. I was wondering if I could possibly interview you. This can include anything from notable technological advancements to major wars. Can I interview you about a historical event you have experienced? We can have a preliminary interview to decide what to do it on too if you want. Thank you for considering, and it's totally fine if this doesn't work for you."

I, 9:14 pm, "Sure I'd love to. Suggest a time."
We arranged for Friday at 3 pm.

I thought about several events, such as the terrible scouting accident in Carcass Wash, en route to float the Colorado River from Hole-in-the-Rock on June 10, 1963, where thirteen died; and the terrorist attacks on the USA on September 11, 2001. But I decided to talk about the discovery of Cold Fusion.

Here's how I replied:
- - -
from: Tracy Hall Jr <hthalljr@gmail.com>
to: Hazel Grace Wheeler <hazel.g.wheeler@gmail.com>
cc: Helen Hall <helenvh@gmail.com>,
Dean Wheeler <battwheel@gmail.com>,
Zina Hall Wheeler <zinawheeler@gmail.com>,
Ike Wheeler <ickaser@gmail.com>,
David R Hall <dhall@halllabs.com>
date: May 5, 2022, 1:42 PM
subject: Background for our oral history interview tomorrow

Dear Hazel,

The event that I'd like to talk about is one which I believe will someday prove to be the greatest material benefit to mankind since the discovery of fire: "cold fusion." But it's not yet past history: it's still future history!
The fact that he is a "true believer" in "cold fusion" marks your Grandpa as crazy, but you already knew that! So, if you dare to be associated with such craziness, that's what I'd like to talk about.
Thanks to a tip from your uncle Tracy, I was able to attend the press conference at the University of Utah on March 23,1989, when Pons and Fleischmann announced their discovery. I listened to each

of them and immediately afterward went to their lab, where the graduate student who had helped them with the experiments explained them to me in detail. With funding and encouragement and a research assistant provided by my brother David, and working essentially 24/7, we were able, within about 2 months, to replicate their discovery. We presented our results to the Utah state agency that had received special funding for cold fusion, but they had already decided to limit all funding to the University of Utah.
Soon thereafter, the "powers that be" in world science declared that "cold fusion" was a fraud. David and I realized that this would be a long-term effort and that we couldn't fund it ourselves, so we went back to working on our bread-and-butter research in polycrystalline diamond materials for rock drilling. For a third of a century now, hundreds of workers have continued to work in the field, with private funding, and much progress has been made, but "cold fusion" still hasn't reached the point of reliable reproducibility.

If you get a chance before we talk, watch the first link below, a 25-minute video by Matt Lilley. He gives an excellent summary of the history, and I really like his attitude about transparency in science. Working on a shoestring, he's trying himself to replicate some remarkable results made by a Japanese researcher, Tadahiko Mizuno and is posting all his results to GitLab.com. Mizuno himself has been completely transparent in trying to help others to reproduce his results.
Mizuno and Lilley have even inspired me to consider dipping my toe back into "cold fusion." After all, I'm retired: who's gonna fire me! It would be so fun, next winter, to be able to run a 3,000 watt space heater with only 300 watts of input!

If you have any questions about the science, your Dad and Ike probably could explain it better than I could. Also, you might call Uncle Tracy and ask about his recollections about giving me the tip about the press conference, and he or your Mom might remember how I essentially went missing for a couple of months in my effort to reproduce the "Fleischmann-Pons effect."

Lilley's history of cold fusion: https://www.youtube.com/watch?v=JFwxlRu7tnU
Mizuno's recipe: https://www.lenr-canr.org/acrobat/MizunoTincreasede.pdf
Mizuno's supplemental hints: https://www.lenr-canr.org/acrobat/MizunoTsupplement.pdf

Love,

Grandpa Tracy

PS: David, Hazel has an assignment in school to interview someone who witnessed some important event in history. Please feel free to copy us with your recollections. Are you still a "true believer?"
- - -

David, who with his wife Karen is serving in the Texas Houston East mission, answered me in about half an hour:

- - -
from: David Hall - Hall Labs <dhall@halllabs.com>
to: Tracy Hall Jr <hthalljr@gmail.com>
cc: Hazel Grace Wheeler <hazel.g.wheeler@gmail.com>,
Helen Hall <helenvh@gmail.com>,
Dean Wheeler <battwheel@gmail.com>,
Zina Hall Wheeler <zinawheeler@gmail.com>,
Ike Wheeler <ickaser@gmail.com>,
Huntington Tracy Hall <hthall@halllabs.com>,
Michael Hall <mhall@halllabs.com>,

Jeff Duncan <jduncan@halllabs.com>
date: May 5, 2022, 2:16 PM
subject: Cold Fusion

Tracy

Halllabs is willing to commit to and fund a long term cold fusion project if you can find a willing competent researcher to join Halllabs to focus on this.

I agree that it is the future of energy.

I am willing to start funding at $1M per year to start and allocate much more if promising results start to emerge.

Finding the right person is the first key. You?

David R Hall
801-358-0789
- - -
It took me about an hour to compose my thoughts and share them with David:

from: Tracy Hall Jr <hthalljr@gmail.com>
to: David Hall - Hall Labs <dhall@halllabs.com>, Helen Hall <helenvh@gmail.com>
date: May 5, 2022, 3:26 PM
subject: Re: Cold Fusion

Wow! I had no idea you were still just as crazy as I am! ;)
I'm sharing these thoughts just with you and Helen. If you feel the same way I do about the way forward, I'm ready to go ahead, on a hand shake.
What I was starting to think about was a shoestring hobby operation in my basement, just to try and replicate Muzino's work and see what might go from there, so your generous offer amazes and inspires me.
I'm not sure I could even spend $1M a year, and I'm certainly not eager to assume any kind of managerial role. But it would be great to work in a nice facility with access to designers and a machine shop, with perhaps the help of a capable technician or two, and with the chance to freely exchange ideas with others, both in Hall Labs and throughout the world.
I've come to believe that nobody can own cold fusion: it's too big to patent. Even if you come up with a truly unique patentable solution that has no elements anticipated by others (which I actually believe is impossible), if you succeed in obtaining patents, you would spend the rest of your life in litigation with thieves and bullies. But share it with the world in real time, both the failures and the successes, and you're safe from thieves and bullies.
That's where Utah state and the U of U went wrong in 1989 -- they had the chance to lead a joint world effort and lost it by trying to hog the IP.
Also, it would be impossible to enforce any patents in the world's most populous countries, and it would actually be very dangerous to possess the secret alone. If suddenly it became known that you could put the Russians, Arabs, Venezuelans, and even certain Texans, out of the energy business, you and all your loved ones would be in great danger!
So I think the best way forward is to freely share everything that we can discover, in real time, with the world, as a humanitarian project. It would be good to have some faithful Latter-day Saints involved who might eventually bring credit to the Church for their useful contributions. There's great safety in numbers and great benefit in working with others toward a common goal.

Thanks to your prior generosity, I already have sufficient for my needs and would freely contribute my time and efforts to such a humanitarian, open-source project. If properly structured as a non-profit, you might even be able to take your contributions as a tax deduction. I've followed the work of dozens of researchers over the years and believe that the Lord has inspired some really brilliant and good people to do excellent work, many of whom are now retired and are our age or even older. It would be fun to find a way to work together with the best of them to discover the solution and to share it with the world.

Let me know your thoughts.

- Tracy
- - -
David sent the following 9 minutes before I sent my thoughts, but I didn't see them until after sending it:

from: David Hall - Hall Labs <dhall@halllabs.com>
to: Tracy Hall Jr <hthalljr@gmail.com>
cc: Hazel Grace Wheeler <hazel.g.wheeler@gmail.com>, Helen Hall <helenvh@gmail.com>, Dean Wheeler <battwheel@gmail.com>, Zina Hall Wheeler <zinawheeler@gmail.com>, Ike Wheeler <ickaser@gmail.com>,
Huntington Tracy Hall <hthall@halllabs.com>, Michael Hall <mhall@halllabs.com>, Jeff Duncan <jduncan@halllabs.com>
date: May 5, 2022, 3:17 PM
subject: Cold Fusion research by Halllabs

I also agree that all research done by any company or institution needs to be open source like the Web because no one can own it plus not one person alone will solve it. It needs to be thousands of individuals or even millions working on it to solve it.

Halllabs is willing to fund the Research completely open source with no patents and no exclusive ownership. Plus no waiting to publish successes or failures. Open source in the truest way.

Halllabs reason to fund is that we are believers in the basic concept …. and we need it for the future full success of the NewVistas concept …and the NewVistas foundation is Halllabs only beneficiary now that Halllabs is in a trust.

- - -
To which I immediately replied:

from: Tracy Hall Jr <hthalljr@gmail.com>
to: David Hall - Hall Labs <dhall@halllabs.com>
cc: Hazel Grace Wheeler <hazel.g.wheeler@gmail.com>, Helen Hall <helenvh@gmail.com>, Dean Wheeler <battwheel@gmail.com>, Zina Hall Wheeler <zinawheeler@gmail.com>, Ike Wheeler <ickaser@gmail.com>,
Huntington Tracy Hall <hthall@halllabs.com>, Michael Hall <mhall@halllabs.com>, Jeff Duncan <jduncan@halllabs.com>
date: May 5, 2022, 3:28 PM
subject: Re: Cold Fusion research by Halllabs

Tracy Hall Jr <hthalljr@gmail.com>
Thu, May 5, 3:28 PM (8 days ago)
to David, Hazel, Helen, Dean, Zina, Ike, Huntington, Michael, Jeff

My goodness! This came one second after I sent you my thoughts. We're in perfect agreement. Let's do it!

- Tracy
- - -
from: David Hall - Hall Labs <dhall@halllabs.com>
to: Tracy Hall Jr <hthalljr@gmail.com>
cc: Hazel Grace Wheeler <hazel.g.wheeler@gmail.com>, Helen Hall <helenvh@gmail.com>, Dean Wheeler <battwheel@gmail.com>, Zina Hall Wheeler <zinawheeler@gmail.com>, Ike Wheeler <ickaser@gmail.com>,
Huntington Tracy Hall <hthall@halllabs.com>, Michael Hall <mhall@halllabs.com>, Jeff Duncan <jduncan@halllabs.com>
date: May 5, 2022, 3:48 PM
subject: Re: Cold Fusion research by Halllabs

Ok let's start it up again.

Huntington can help you get you set up at the lab with an office and work area and a Cold Fusion class code to charge expenses to.

Michael can help you figure out to find help and how to get computers and equipment and a company cc and how to allocate expenses.

You would be responsible for heading it up and hiring help if needed.

Since your willing to work for free we don't need to worry about payroll for you.

David R Hall
801-358-0789
- - -
from: David Hall - Hall Labs <dhall@halllabs.com>
to: Wendy Coplen <wcoplen@halllabs.com>, Carl Belliston <cbelliston@halllabs.com>
cc: Support-Hall Labs <support@halllabs.com>, Huntington Tracy Hall <hthall@halllabs.com>, Michael Hall <mhall@halllabs.com>, Brett Wilkey <bwilkey@halllabs.com>
date: May 5, 2022, 4:38 PM
subject: Cold Fusion research project by Halllabs www.Tracy.com

Wendy

Tracy Jr. will head up a renewed Cold fusion project.

Will need

1) cc with $5,000 limit
2) office, computer, lab area
3) training on how to allocate
4) a class code for project.

5) halllabs email account

Web site for project will be the Tracy.com site we were using for materials.

Sky will repurpose web site with help from Tracy jr and Huntington

David R Hall
801-358-0789
- - -
Here's what I posted that evening to my public Facebook page: 66 of my FB friends reacted, and 39 commented, and several expressed a desire to help.

https://www.facebook.com/permalink.php?story_fbid=10159257757756107&id=578136106
Tracy Hall Jr
May 5 at 7:10 PM
In amazing chain of events happened today, triggered by a request from my granddaughter Hazel to interview me, for a school assignment, about any important historical event that I might have witnessed.
As I thought about it, I had to confess to myself that nothing has occupied my daydreams more for the last third of a century than that resulting from an announcement made on the 23rd of March, 1989 at the University of Utah in Salt Lake City, by Stanley Pons and Martin Fleischmann. Thanks to a tip from my son Tracy, I was able to be present for that announcement. I "wandered" into their laboratory and interviewed the graduate student who did much of the hands-on effort, and I then spent a hectic two months, almost 24/7, to successfully duplicate that result. That effort was encouraged and funded by my brother and employer at Novatek, David R. Hall, but we ran out of money, couldn't obtain funding for it, and had to return to our bread-and-butter project of developing polycrystalline diamond cutters for oil and gas drilling.
When I suggested the topic to my granddaughter, I copied my reply to David, asking if he had any memories of that event to contribute, and I confessed that I was again thinking of dipping my toe, as kind of a hobby, into "cold fusion" research.
COLD FUSION???
Yes, I'm still that crazy, and so, it turns out, is David!
Almost immediately, he offered to fund and facilitate a long-term effort to continue this research, at Hall Labs, with up to $1 million promised for the first year. It turned out that we were both still thinking a lot about it, and that we had independently arrived at the conclusion that the only way forward was to do it as an open source project, freely inviting participation from anyone and sharing the results freely with mankind. It will be done as a humanitarian, non-profit effort, under the umbrella of Hall Labs.
Because of David's earlier generosity to me in the sale of IntelliServ, where I was a co-inventor, I was able to retire early in 2005. I've spent most of my time since then in missionary and family history efforts, but I still have sufficient funds for my continuing needs.
So at age 76 I'm coming out of retirement! I will contribute my time, David will contribute his organizational skills, facilities, and funds, and with the help of anyone who is willing to freely participate, we'll get this job done!
As I write this, a passage in Exodus comes to mind:
"Then wrought Bezaleel and Aholiab, and every wise hearted man, in whom the Lord put wisdom and understanding to know how to work all manner of work for the service of the sanctuary, according to all that the Lord had commanded.
"And Moses called Bezaleel and Aholiab, and every wise hearted man, in whose heart the Lord had put wisdom, even every one whose heart stirred him up to come unto the work to do it."
(Exodus 36:1-2)
David and I aspire to be like Bezaleel and Aholiab!
- - -

Signed Friday, May 13, 2022, 2:50 pm, Albuquerque, NM
*****
Mon May 30, 2022, 10:26 AM
I went into Hall Labs for the first time on Friday, May 27 to meet Sky Evans and Tiffany ____, who set me up with an email account, hthalljr@halllabs.com, gave me a wireless fob to allow me to enter outside of hours (8 am to 5 pm), and set me up as an employee of Hall Labs with a salary of zero. I met separately with Micheal Hall, Scott Woolston, and my son Tracy to learn a little bit about how things function at the lab and to share my initial thoughts about the direction I want to take. By Saturday evening I had fleshed out my ideas a little bit: much research and thinking still to go. I'm thinking simply of calling it "very cold fusion."
- - -
from: Tracy Hall Jr <hthalljr@gmail.com>
to: David R Hall <dhall@halllabs.com>, Michael Hall <mhall@halllabs.com>, scottwoolston@halllabs.com, [bounced: I then forwarded it to Scott.woolston@gmail.com. His correct address is swoolston@halllabs.colm], Huntington Tracy Hall <hthall@halllabs.com>, Helen Hall <helenvh@gmail.com>
date: May 28, 2022, 9:41 PM
subject: Building on our 1989 replication of the Fleischmann-Pons effect

After digging through many boxes, I found our report on the research we conducted, from March 23 to August 22, 1989. If I must say so myself, we did some pretty good work. We may have accomplished the first-ever real-time measurement of D/Pd loading in an electrolytic cell, and we anticipated the importance of some things that others later confirmed. By August, however, the scientific establishment had poisoned the well, and nobody was going to publish this kind of nonsense. So our work has been sitting in boxes for 33 years. Maybe someday we can unbox our beautiful gadget and add it to the little museum!

From the get-go, we believed that superconductivity might be playing an important role, and our experiment was designed to look for that. We didn't find it, but I think I now understand better why, and I'm eager to look for it again. If cold fusion can be induced at cryogenic temperatures, hopefully as warm as liquid nitrogen (77 K), but colder if necessary, then maybe it can finally be tamed. My hope is that instead of coupling the energy of fusion via baby-steps into teraherz optical phonons (heat), it might be coupled via baby-baby-steps into gigaherz microwaves (electricity!) We'll look first for a metal-D system that has superconductivity. Superconductivity in a D-metal system might never be found in bulk, but some fascinating work by a group in Australia suggests that in Pd-D, a continuous network of superconducting filaments can occasionally be obtained by rapidly quenching a Pd wire in 1500 psi of D_2 from 300 C to 40 K.
If we find such a material, we'll fabricate a microwave cavity from it, couple it to a waveguide, cool it down, and then . . . wave a magic wand. I'll flesh out the concept over the next few days and run it past you all. Then, with your feedback, I'll put it out there for the public to contemplate.

Here is a brief summary and discussion of our earlier work.

We built a first-law calorimeter that ran a plastic coil with high surface area directly through the electrolyte. By measuring the flow of the cooling water and the inlet and outlet temperatures, we got an accurate measurement of total heat evolved from the system. Anything that exceeded the measured Joule heating would be the excess heat we were looking for.

We made a huge Palladium cathode weighing 10.3 grams, 1 mm in diameter and 1.07 meters long, which was wound in 19 turns on a slotted PTFE (Teflon) mandrel. One of the reasons we made it so big was to get meaningful amounts of heat. From the outset, we wanted to see if superconductivity played a factor in the F-P effect, so we connected 22 electrical leads along the length of the cathode to facilitate resistivity measurements, section by section. (The cathode current was fed out in parallel on these leads so as to equalize current density along its length; otherwise the entire current would have all had to exit through one end, with undesirable resistance heating.) We hoped to measure the resistance of each section during electrolysis using Ohm's law, from the operating current and voltage, but random generation of bubbles that isolated tiny portions of the cathode from the electrolyte resulted in random current dips and spikes that defeated any real-time resistivity measurement. We had even hoped to measure resistivity vs depth by using the skin effect in an AC measurement over a wide range of frequencies but never got to that. (In retrospect, I believe that 22 four-point resistivity circuits could, in fact, have been electrically isolated from the electrolysis circuit and used to make both DC and AC resistivity measurements in real time.) We did briefly pause the electrolyzing current but saw no substantial change in resistance.

After a series of runs that began on May 15, our cathode had been electrolyzed for 170 hours without seeing excess heat. We finally succeeded in run 3B, on July 18-19. I believe that the early trials did, in fact, alter the Pd microstructure to become more fusion-friendly. During that run, after 2 hours of charging with high current densities and aggressive cooling, we observed substantial excess heat for a period of 5 hours. Peak excess heat was 16.3% (108.8 watts in, 126.5 watts out). The time-averaged excess heat was 11.4%. We were unable to reproduce this result and ran out of time and money. Indeed excess heat often appears to have a finite life before the active sites somehow wear out or dissipate. This is another reason to try to do it all at much lower temperatures, where diffusion and mechanical creep get frozen. Also, H and D absorption is a strong function of temperature: increasing the temperature always drives out the gas; lowering it draws it in.
Our cathode was large enough that the Pd/D ratio could actually be measured by weighing it. We cleaned the black smut of the cathode with detergent in an ultrasonic cleaner, rinsed it in alcohol, dried it, and weighed it. (Hmm. Maybe we washed away the magic?) We could actually watch the weight drop as deuterium leaked out of the Pd. In early, low-current runs, the D/Pd ratio, established by weighing after the run and extrapolating back in time, measured 0.59, 0.46 and 0.61. The need, of course, was to measure how much D went into the Pd in real time. The idea was to maintain a closed system by repeated arcing of a spark plug, which would recombine the D2 evolving from the Pd cathode with the O2 evolving from the Pt anode. Since some of the D2 would be entering the cathode, there would be extra oxygen that had nothing to burn. This excess O2 was collected and measured precisely in a gas burette. The method worked great, but only at low electrolyzing current. At higher currents, increased bubbling and splattering shorted out the spark plug.

In run 2a (June 24) we measured, after 6 hours of operation at low current density, by evolution of excess O2, a D/Pd ratio of 0.96; in run 2B (June 25), again at low current density, we were able to change the cell temperature with an electric heater and observed D/Pd of 0.83 at 22 C, which dropped to 0.79 at 40 C, which I interpret as a manifestation of the strong temperature dependence of the D/Pd ratio. But in successful run 3B we drove the current so high that we had to run it as an open system: the bubbles and splashes shorted out the spark plug. (Later on, others facilitated highly efficient O2/D2 recombination with platinized porous ceramic catalysts. During run 3B we did measure the evolution of O2 + D2 with time, and it corresponded exactly with the expected Faraday yield (one ampere is one coulomb of charge per second, which is converted to moles of electrons and moles of gas).
In later years, meticulous studies by Michael McCubre's group at Stanford Research Institute revealed the importance of obtaining high D/Pd ratios, and they established a calibration curve of D/Pd concentration as a function of relative resistance. If high D/Pd tatio alone had sufficed, our ratios of .83 to .96 should have produced excess heat in runs 2A and 2B, but it was not detected. In run 3B the current was so high that D/Pd was undoubtedly greater than 1, and our configuration, which produced an asymmetric electric field around the cathode, gave us, by a happy accident, the high D flux through the cathode which McCubre later emphasized as important.

I've attached some suggested reading. Of greatest interest: the work of Syed at. al. on quenching in superconductivity in the Pd-D system. They made no mention of the possibility of cold fusion, and I can find no follow-up work. Did they discover something anomalous and continue this work in secret?

- Tracy Jr

Four Attachments:
1. “2002 McKubreMCH need for triggering.pdf” 446 KB
McKubre, M.C.H. The Need for Triggering in Cold Fusion Reactions. in Tenth International Conference on Cold Fusion. 2003. Cambridge, MA: LENR-CANR.org. This paper was presented at the 10th International Conference on Cold Fusion. It may be different from the version published by World Scientific, Inc (2003) in the official Proceedings of the conference.
https://www.researchgate.net/publication/241489694_The_Need_for_Triggering_in_Cold_Fusion_Reactions

2. “2016 Sayed et al Superconductivity PdH & PdD 52-61K_1608.01774.pdf” 1.7 MB
Superconductivity in palladium hydride and deuteride at 52–61 kelvin
H. M. Syed, T. J. Gould, C. J. Webb and E. MacA. Gray*
Queensland Micro- and Nanotechnology Centre, Griffith University, Nathan 4111, Brisbane, Australia
https://arxiv.org/ftp/arxiv/papers/1608/1608.01774.pdf

3. “2015-02 McKubre Cold-fusion-comments-on-the-state-of-scientific-proof.pdf” 564 KB
“Cold fusion: comments on the state of scientific proof”
Michael C. H. McKubre, SRI International, Menlo Park, CA, USA
Current Science, Vol. 108, No. 4, 25 February 2015
https://drmyronevans.files.wordpress.com/2015/01/cs-1.pdf

4. “2006-02 Dardik et al super wave loading, glow discharge loading.pdf” 6 MB
Excess Heat in Electrolysis Experiments at Energetics Technologies
I. Dardik, T. Zilov, H. Branover, A. El-Boher, E. Greenspan, B. Khachatorov, V. Krakov, S. Lesin, and M. Tsirlin
11th International Conference on Cold Fusion ICCF-11, Marseilles, France, November 1-6, 2004
https://www.researchgate.net/publication/228842312_Excess_heat_in_electrolysis_experiments_at_Energetics_Technologies

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