Search for the Origins of the Anomalous Heat Effect (AHE) in Deuterium-loaded Palladium Driven Far From Equilibrium

July 3, 2012

ILENR Conference
College of William and Mary

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Discovery is Creatively Disruptive

*If we all worked on the assumption that what is accepted as true is really true, there would be little hope of advance.*
- Orville Wright

*The flying machine which will really fly might be evolved by the combined and continuous efforts of mathematicians and mechanicians in from one million to ten million years.*
- The New York Times, Oct. 9, 1903

We started assembly today.
- Orville Wright's Diary, Oct. 9, 1903
A Long History of ‘Cold Fusion’ Reports

• First report of a possible nuclear fusion in palladium loaded with hydrogen: Berlin, Germany, September 17, 1926 by Professors Paneth and Peters, later retracted due to helium in glass.

• Some patent activity in and after 1927 by Tandberg in Sweden

• Detection of confirmed nuclear fusion in liquid heavy hydrogen at -422 F (-252 C) in Russia, Berkeley and other places from 1954 to 1959. This fusion is catalyzed by naturally occurring muons

• Fleischmann and Pons (FP) fateful Press Conference on March 22, 1989
Excess Heat Result from Energetic Technologies in 2004

\[ P_{\text{Out Max}} = 34.4 \, \text{W} \]

\[ \text{Duration} \sim 14 \, \text{Hours} \]

\[ E_{\text{out}} = 1.1 \, \text{MJ}, \quad E_{\text{in}} = 40 \, \text{kJ} \]
The Excess Heat Effect: far Greater than Chemical Heat Release

• The ET Pd cathode mass was 0.3 g \( (2 \times 10^{-3} \text{ mole}) \)
• Chemical release of heat:
  – \( \Delta H \) for \( \text{Pd} + \text{D} \rightarrow \text{PdD} \) is about 43 kJ/mole
    • So about 100 J if this heat release was somehow delayed
  – \( \Delta H \) for \( 2\text{D}_2 + \text{O}_2 \rightarrow 2\text{D}_2\text{O} \) is about 242 kJ/mole
    • So about 500 J of delayed released heat
• Many measurements show:
  – Typical heat release per episode of 50,000 J
  – Occasional heat release of over 1,000,000 J
• Heat release is usually from ambient temperature to about 100 °C, with occasional reports of heat release at much higher temperatures
So What is Going On?

• We don’t know – it will take a lot of well controlled experiments to figure this out.
• The ‘excess heat’ is real, and this has been confirmed by NRL, ENEA, and many other labs. That is enough to motivate serious study.
• A nuclear process?
  - Fusion? Look for nuclear by-products
  - LENR? First electro-weak nuclear energy release? If so, look for cold neutron effects
  - Something else?
Junk Science or Empirical Data?

- Persistent observations, like excess heat in Pd – D, should be treated as empirical evidence that our understanding of physics remains incomplete.
- It is simply too convenient and too scientifically counter-productive to dismiss these observations as ‘junk science’.
- The Scientific Method is the only thing we have got, and fortunately it is the only thing that we need!
  - Simply apply the scientific method without prejudice, and go where the data leads you
Sidney Kimmel Institute for Nuclear Renaissance (SKINR) at MU

$5.5 Million gift, plus equipment, Five-year minimum duration

SKINR’s objective is to determine the physical origin of the Anomalous Heat Effect

“I chose MU for this important gift because it is a comprehensive university, experienced in using its deep scientific research capacity across many fields with its firm commitment to serve the public good.”
The Sidney Kimmel Institute for Nuclear Renaissance (SKINR)

• Established on a $5.5M gift from Sidney Kimmel
• Exclusive license to utilize all of Energetic Technologies’ prior technology and IP
• Dedicated to applying the Scientific Method to determine the origins of the AHE
• Secondary mission to secure relevant additional IP as the science develops
• Dedicated to open publication and transparency is our scientific mission
SKINR’s Scientific Focus

• **Always** run careful controls (hydrogen vs. deuterium) in all experimental loading techniques, including ‘electrolytic’, ‘implant’, and ‘gas loading’.

• Be ‘hypothesis driven’ throughout. What are we trying to **disprove**?

• Characterize the Pd metal surfaces carefully, and evaluate surface changes in all samples regardless of the level of excess heat release – standardize the protocol – utilize ‘top-down’ fab and ‘self-assembly’

• Comprehensive chemical analysis and isotope abundance determinations
SKINR’s Scientific Focus (Con’t)

• Extend the parameter ranges of loading
  – Gas Loading: P up to 200 bar, T down to 20 K
At 10 MW, MURR is the largest neutron source on a US campus and provides a flux competitive with national user facilities. It has a total of six beam ports, three of which are presently dedicated to four neutron scattering instruments: a triple-axis spectrometer (TRIAX), a neutron reflectometer (NR) and two double-axis diffractometers (2X-C and PSD).
SKINR’s Scientific Focus (Con’t)

• Neutron scattering to determine the structure and dynamics of the hydrogen / deuterium system; x-ray scattering to determine Pd lattice
SKINR’s Scientific Focus (Con’t)

Implant Loading… Energy from ‘discharge loading’ up to the Coulomb barrier (cyclotron)

In a big radiation vault, so we bring the beam out to impinge on target

D+ on naturally occurring Pd targets
D+ on natural Pd loaded with D
p on naturally occurring Pd targets
p on $^{64}$Ni

General Electric, 16.8 MeV p accelerator (MU and Essential Isotopes, LLC)
SKINR’s Scientific Focus (Con’t)

• Neutron activation analysis to search for ‘cold neutron’ effects (data below from Firestone, et al.)
• See Bush and Lagowski: Trace Elements Added to Palladium by Electrolysis in Heavy Water, EPRI, Palo Alto, CA: 1999 (TP-108743): $^{108}\text{Pd}/^{110}\text{Pd}$ down 28%!

- Determine $^{108}\text{Pd} / ^{109}\text{Ag}$ stable isotope ratio

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SKINR’s Scientific Focus (Con’t)

- Use diamond substrate particle detectors to check for internal conversion

See Mark Prelas and Eric Lukosi for more information. Figure copied from A. Galbiati et al., IEEE Transactions on Nuclear Science, Vol. 56, No. 4 (2009), 1863-1874.

- Local fields (NMR) to search for molecular formation and crystal lattice position
- external initiation trigger measurements
- New novel experimental configurations that have displayed results, such as a new on-demand neutron source
### Possibility of fast valance fluctuations?

**Ni**: $4s^2\ 3d^8$

**Pt**: $6s^0\ 5d^{10}$

but Pd switches, hence Stoner Enhancement, etc.

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Actinide Series~

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Space flight is the only way to avoid $\xi_g$


Successful CDR in 2003

cancelled in 2004

All 117 ‘ClassB’ approved hardware drawings are in place.

Need:
- new PI team
- flight dewar
- platform
- ride
‘T5’ Critical Thermal Path
Conclusions / Recommendations

• Follow the Scientific Method to determine the physical mechanism
• Encourage all funding agencies to be more empirically evidence-based as well
• Expand experimental techniques and the range of physical measurements
• Create a more formal international trade organization, and meet to standardize terminology, and to develop standards
• Open Source versus Proprietary approaches