Evidence for Deuteron Stripping in Metals That Absorb Hydrogen

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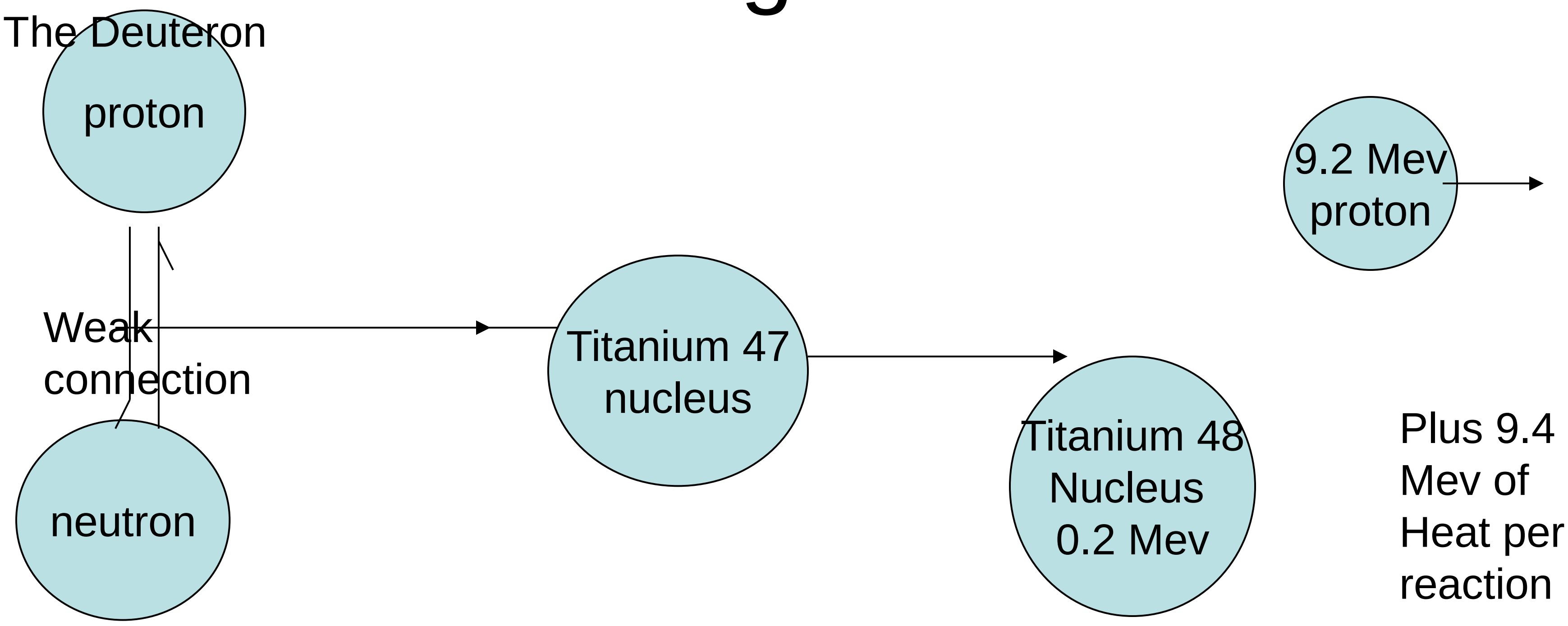
The Neutron Activation Analysis (NAA) Methodology

- Much of the Evidence favoring the Deuteron Stripping Reaction Hypothesis is Based on NAA Data Showing Differences Between Virgin and Heat-Producing Metal Samples
- Using Irradiation of a pair of samples in a nuclear research reactor, we measure RATIOS of Gamma Rays Emitted Post Irradiation Rendering Moot issues involving differences in sample handling and analysis procedures
- This Focuses on **Differences** Caused by ONLY the Excess Heat Production Process

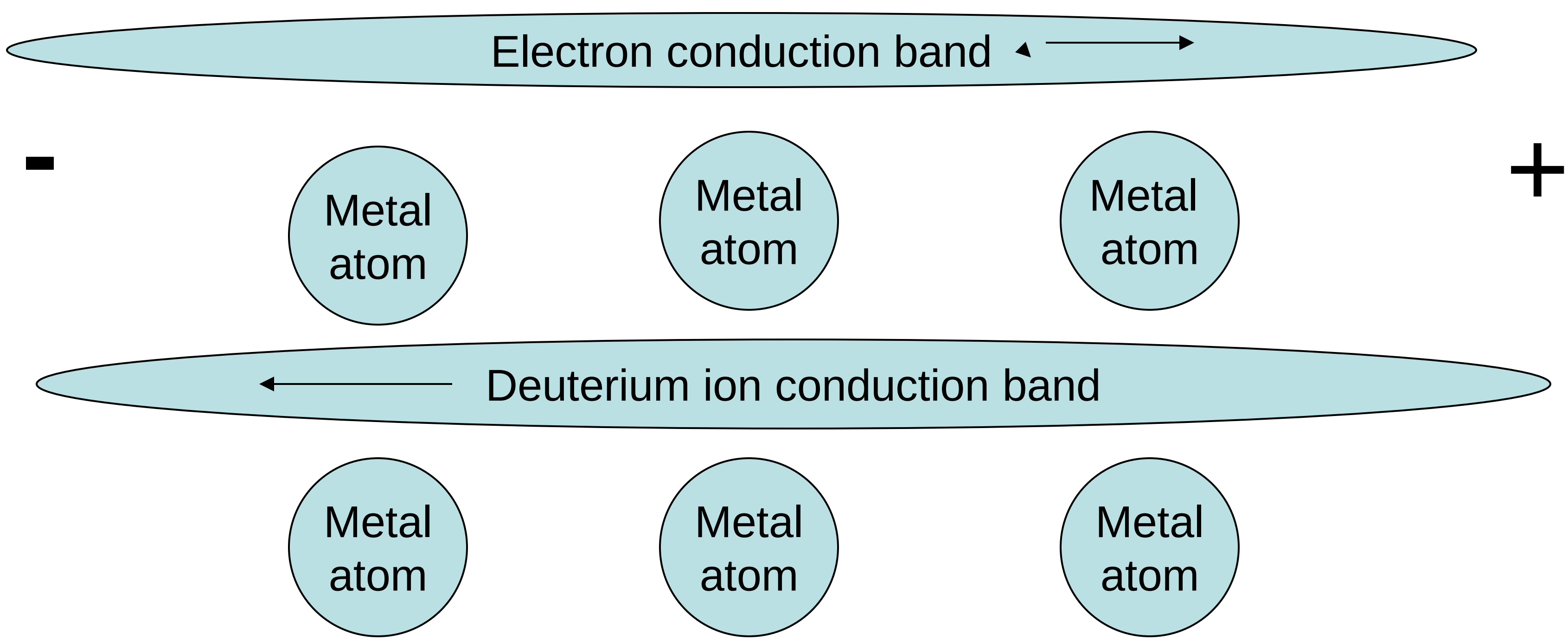
23 Metals known to Absorb & Allow Transport of D/H Within The Lattice

- Palladium(46) Scandium(21),Yttrium(39)
- Titanium(22),Zirconium(40),&Hafnium(72)
- Vanadium(23),Niobium(41)&Tantalum(73)
- Lanthanum(57) thru Neodymium(60)-4 ea.
- Samarium(62) thru Lutecium(71)-10 ea.

The Deuteron Leaving its Neutron behind in a Ti-47 Nucleus Having Been Stripped of Its Proton and Producing Heat



Schematic of Electron and Deuterium-Ion Conduction Bands in Metals That Absorb Deuterium



These two Conduction Bands May Comingle
Under Dynamic conditions of High Deuteron Fluxes

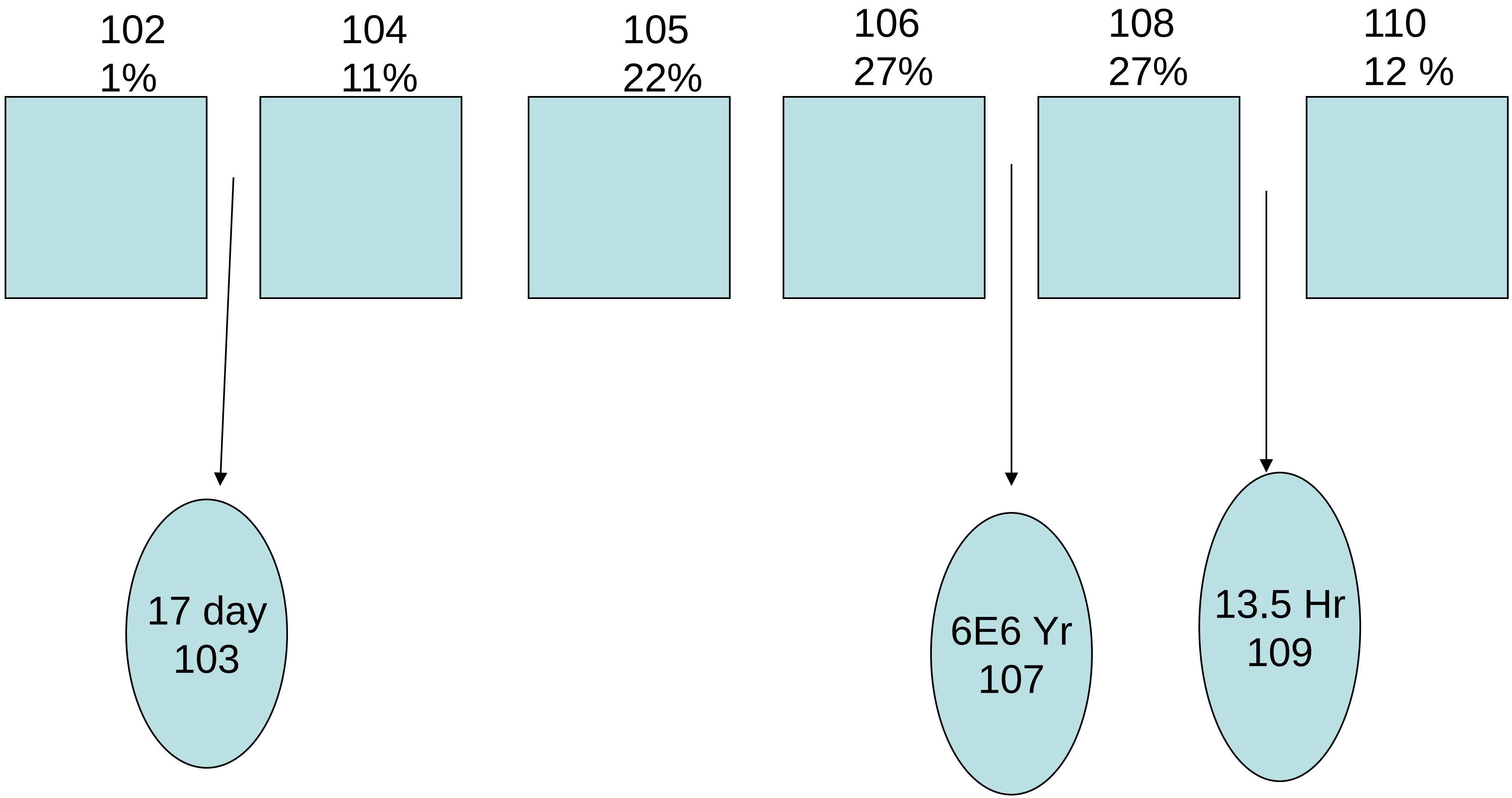
Evidence Supporting the (D,P) Oppenheimer-Phillips Reaction as Excess Heat Source In Pd

- Gozzi Group@ U.of Rome Recorded (on X-Ray Film) 89(1) keV Gamma Rays Emitted by Pd-Wire-Bundle Cathode During150 of a 1000 Hour Electrolysis while 2.5 Megajoules of Excess Heat Were Also Being Measured (9.3 MJ in 1000 hrs)
- The Gamma Ray Energy Coincides With the 88.03 keV Gamma of 13.5 hour Pd^{109} Beta Decay to Ag^{109}
- Likely Source of Pd^{109} is $Pd^{108}+D \rightarrow Pd^{109}+P$ (Q=3.9 Mev)
- Similar Reactions on the Other 5 Pd Isotopes would Produce Heat but Gammas of negligible intensity relative to that of the 88 keV Gamma ray

How Can a Deuteron Prefer to React with Hi Z Metal Atoms Rather than with another D?

- The appearance of Pd109 associated with excess heat episodes is a **Major Surprise**!!
- Assuming Our Interpretation of the 89(1) keV photons Recorded in X-Ray Film by Gozzi et.al. is from Pd109 decay, clearly the coulomb barrier at Z=46 has been circumvented
- Deuterons must prefer to react with stationary atoms in the metal than with other deuterons in rapid motion through the ion conduction band

Six Stable & 3 Radioactive Palladium Isotopes



Corroborating Evidence For Stripping of Deuterons in Pd

- Shifts in Pd Isotope Relative Abundances Determined by (NAA) After Excess Heat Episodes Show 2 of the 6 Pd Isotopes (102 & 108) Are Being Depleted by 24% & 8% respectively Relative to One of the Other Pd Isotopes (110)
- This Should Not Happen Unless Some or All of the Pd Isotopes Are Being Used Up By Some Nuclear Reaction Whose Probability Varies Among the Six Isotopes ---((d,p) reaction rates WILL Differ)

Silver Production Favoring Ag^{109} over Ag^{107} by >>6 to 1

- Arata/Zhang Reported results of a 180-day Electrolysis with a Hollow Pd Cathode filled with Nano-particles of Pd Producing ~60 Megajoules of Excess Heat. D2 gas >1000 atm in Center chamber containing Pd Particles
- NAA Showed Silver Content of Pd Particles increased by 12 times over the virgin Pd Powder
- The Increased Ag was Predominantly Ag^{109}-- Supports the $Pd^{108}+d \rightarrow Pd^{109}+p \rightarrow Ag^{109}$ as One Source of the Excess Heat

Evidence of (D,P) Reactions in Titanium (Ti)

- Mengoli et.al. at Univ. of Padua Electrolyzed Ti in 0.6 Molar $K2CO3$ in $D2O$ at 95 Deg C and observed ~340 Kjoules of Excess Heat during 20 Days, the Heat Effect Occurring at Open Circuit (Deuterium being exhaled from the Ti)
- Gamma/Gamma Coincidence Detected a Trace of The Radioactive Isotope Sc^{46} Probably from $Ti^{48}+D \rightarrow He^{4}+Sc^{46}$ Reaction with a Q of 4.0 Mev
- Presence of this Rare Reaction implies the Presence of the >>more Probable Heat-Producing (d,p) Reactions on all the Ti Isotopes

Ratio Between Stripping and Compound Nucleus Reactions of the Deuteron with Metal Atoms

- Oppenheimer & Phillips Found Stripping Probability >> Greater than Reactions Requiring Full Entry of the Deuteron (D) Into the Target Nucleus
- Extrapolating From Mev Energies to eV Levels for the Incoming D Gives Expected Stripping to non-stripping reaction Ratios of >>1E6 to One

Six Titanium Isotopes

Ti-46 8.3%
D,p Q=
6.7 Mev

Ti-47 7.5%
D,p Q=
9.4 Mev

Ti-48 73.7%
D,p Q=
5.9 Mev

Ti-49 5.4%
D,p Q=
8.7 Mev

Ti-50 5.2%
D,p Q=
4.13%

Ti-51
5.8 Minute
Half Life
3 Gammas
929,609,320

Evidence for Deuteron Stripping With Impurity Lithium and Boron

- Lithium impurity present in all Metals, esp. in Cathodes electrolyzed in LiOD (diffusion during lengthy electrolyses)
- Boron Widely Present in Pd Metal from Calcium Boride (CaB6) Used to Getter O2 while pouring molten metal in air
- Li^6 and B^{10} are Prime Candidates with (d,p) Q’s of 5.02 & 9.22 Mev Respectively

Lithium 7/6 Ratios by TOF-SIMS Usually Show Li^6 Depletion

- Assuming the (d,p) reaction hypothesis, Only Li^6 has a positive Q (5.02Mev); Li^7 has a **Negative** Q of -0.188 Mev, Preventing ANY reactions with Low eV Deuterons with Li^7
- Any Mev Protons from (d,p) Reactions Can give (p,n) Reactions with Li^7 to Give Be^7 with a threshold of 1.65 Mev But at Very Low Intensity

Boron 10/11 Ratios by TOF-SIMS Often Show B^{10} Depletion

- Assuming the (d,p) Hypothesis, B^{10} has a Q of 9.22 Mev While B^{11}'s Q is Only 1.13 Mev -- which should favor B10(d,p)B11
- B^{10}/Pd^{105} Ratios By PGNAA Almost Always Show B^{10} Depletion Even Though Pd^{105} (Q=7.35 Mev) Could itself be Undergoing (d,p) Reactions
- The Pd99.25%B0.75% Alloy Has Shown Higher Rates of Success Than Pure Pd in Producing Episodes of Excess Heat as Cathodes (Miles)

Q's of Top 10 D Strippers

Isotope	Abundance	Q	Proton Energy
Ti47	7.5%	9.39 Mev	9.2 Mev
Ti49	5.4%	8.71 Mev	8.5 Mev
B10	20%	9.22 Mev	8.4 Mev
Pd105	22.2%	7.35 Mev	7.3 Mev
Ti46	8.3%	6.66 Mev	6.5 Mev
Ti48	73.7%	5.92 Mev	5.8 Mev
Co59	100%	5.30 Mev	5.2 Mev
V51	99.8%	5.08 Mev	5.0 Mev
Pd104	11%	4.57 Mev	4.5 Mev
Li6	7.5%	5.02 Mev	4.4 Mev

Why The Deuteron Can Undergo the Stripping Reaction

- Its two Particles are Just Barely Held Together with the Weakest of All Known Binding Energies (2.2 Mev)
- It is Cigar-Shaped So Its Neutron End Can Occasionally get Near Enough a Metal Nucleus to get Sucked in By the Strong Force While the Proton End is Still Outside the main Portion of the Repelling Coulomb Force Field
- The Proton-Neutron Bond is readily broken and the Proton Carries off Most of the Reaction Q Propelled by Repulsion by the + Charge on the Metal Nucleus

More on the Nature of D’s

- Stuffing Two Particles (a Neutron and a Proton) into a Box Called a Nucleus Has Certain Rules
- The Strong Force has a Limited Range of ~2.4 Fermis (a Fermi=1E-13 centimeters)
- The de Broglie Wavelength (L=h/(mu)v) of 2 Nucleons confined within distance R of each other must have a value <2R where v is the relative velocity of the 2
- Thus the neutron and proton in the deuterium nucleus must have a relative kinetic energy of 71 Mev in an attractive potential well of ~25 Mev
- Thus the n and p of a d nucleus spend about half of their time outside the limits of the strong nuclear force holding them together.

Benefits of Stripping Hypothesis

- No Longer seeking to Quantify Helium-4
- Explains how Nuclear Energy Makes Heat
- Fast Protons Explain Charged Particle Bursts
- Fast Protons Make Neutrons by (p,n) reactions
- Li6+d→p+T & Li7+p→T+Li5 Make Tritium
- Explains Many Transmutations in Metals
- Easier to Confirm or Refute by Search for Gammas among 17 of 23 separate metal elements

Down Side of Stripping Hypothesis

- BIG Coulomb Barriers Fend Off Thermal Energy Deuterons --Lithium (1.4 Mev); Boron (2.0 Mev);Titanium (5.5 Mev); Nickel (6.5); Palladium (8.7 Mev)
- Large Deuteron Fluxes Needed
- Large Coherent Shielding Effects Needed in the Metal’s Ion and Electron Conduction Bands (Raiola’s Poor Man’s Plasma)

Conclusions

- Evidence is strong for The Deuteron Stripping Hypothesis for Producing Excess Heat in Palladium and Titanium
- Need Examples of Excess Heat and Stripping in Other Metals That Absorb Deuterium to Confirm The Hypothesis & Find its Extent of Applicability
- Screening for the Presence of a Radioactive Product of a D,P Reaction in a Deuterated Metal will be easier than the Search for He^4
- Matrix of Experimentation is Very Large if this Hypothesis is confirmed

Total Titanium and Deuterium Supply Vs Global Needs

- Deuterium Atoms in Ocean=7.3E42
- We Need 7.3E42 Titanium or Other Metal Atoms to Strip Them All
- There’s No Shortage of Appropriate Metal Atoms in the Top Meter of the Earth’s Crust
- We get >1E(-12) Joules Per Stripping Reaction
- Stripping Gives ~7E30 Joules Using All The D’s
- 7E9 people Need 2E21 Joules/Yr to Live Like Americans who Use 3E11 Joules/Yr
- Fuel Has Potential to Last 3.5E9 Yrs: Sun’s Life~4E9 Yrs

Titanium Strippings to Provide Power for One Person's Total Annual Energy Needs –(10 kilowatts in U.S.)

- 9.4 Mev Heat per $Ti^{47}+D \rightarrow Ti^{48}+P$
- Ti^{47} is 7.45% of Natural Titanium (nat Ti)
- One Person needs 220 Grams/Yr nat Ti
- For 7 Billion Persons' Annual Needs Requires 1.5 Megatonnes of Titanium/Yr
- There is Enough Ti-47 within the Titanium in the Top 1 meter of 2/3 rds of Earth Crust Area to Last 37,000 Years for 7 Billion People Living American Style