Ultra Low Momentum Neutron Catalyzed Nuclear Reactions on Metallic Hydride Surfaces

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Ultra low momentum neutron catalyzed nuclear reactions in metallic hydride system surfaces are discussed. Weak interaction catalysis initially occurs when neutrons (along with neutrinos) are produced from the protons which capture "heavy" electrons. Surface electron masses are shifted upwards by localized condensed matter electromagnetic fields. Condensed matter quantum electrodynamic processes may also shift the densities of final states allowing an appreciable production of extremely low momentum neutrons which are thereby efficiently absorbed by nearby nuclei. No Coulomb barriers exist for the weak interaction neutron production or other resulting catalytic processes.

The sources of the electron mass renormalization via electromagnetic field fluctuations on metallic hydride surfaces and the resulting neutron production are the main subject matters of this work.

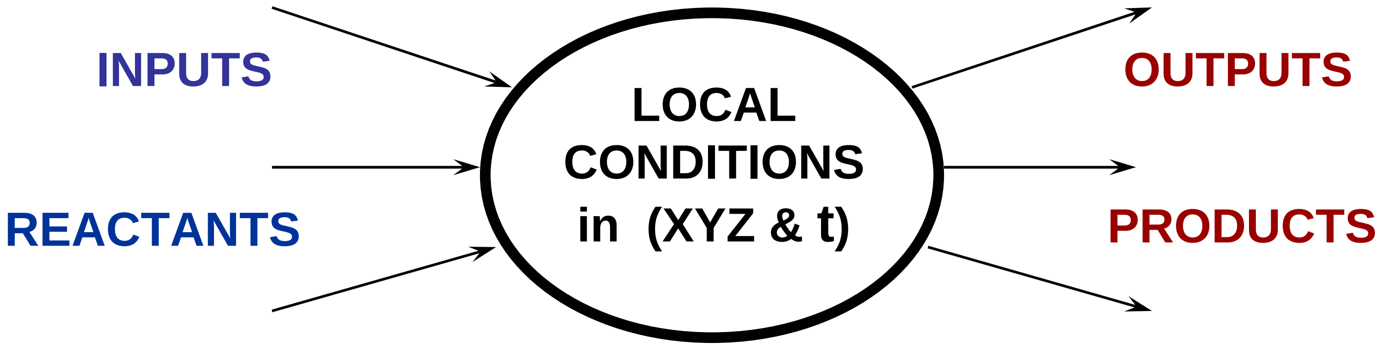
MULTI-STEP PROCESS

1. **H or D at surface of Pd vibrate with large excursions**
2. **The moving H or D interact with surface plasmons to create strong electromagnetic fields**
3. **The EM fields increase the mass ("dress") electrons**
4. **Heavy electrons and H (or D) react via the weak interaction, producing low-momenta (very slow) neutron(s)**
5. **Neutrons react with elements in the experiment.**

The <u>two</u> nuclear reactions in steps #4 and 5 do not have "Coulomb barrier" problems.

They occur within nuclear dimensions, and do not require nuclear wave functions to be distributed in the lattice.

REQUIREMENTS FOR EACH STEP



What are the inputs?

What are the outputs?

What mechanism is involved?

$$< i \,|\, Op \,|\, f >$$

What is the rate of conversion of inputs to outputs?

How do the rates depend on the relevant conditions, such as temperature?

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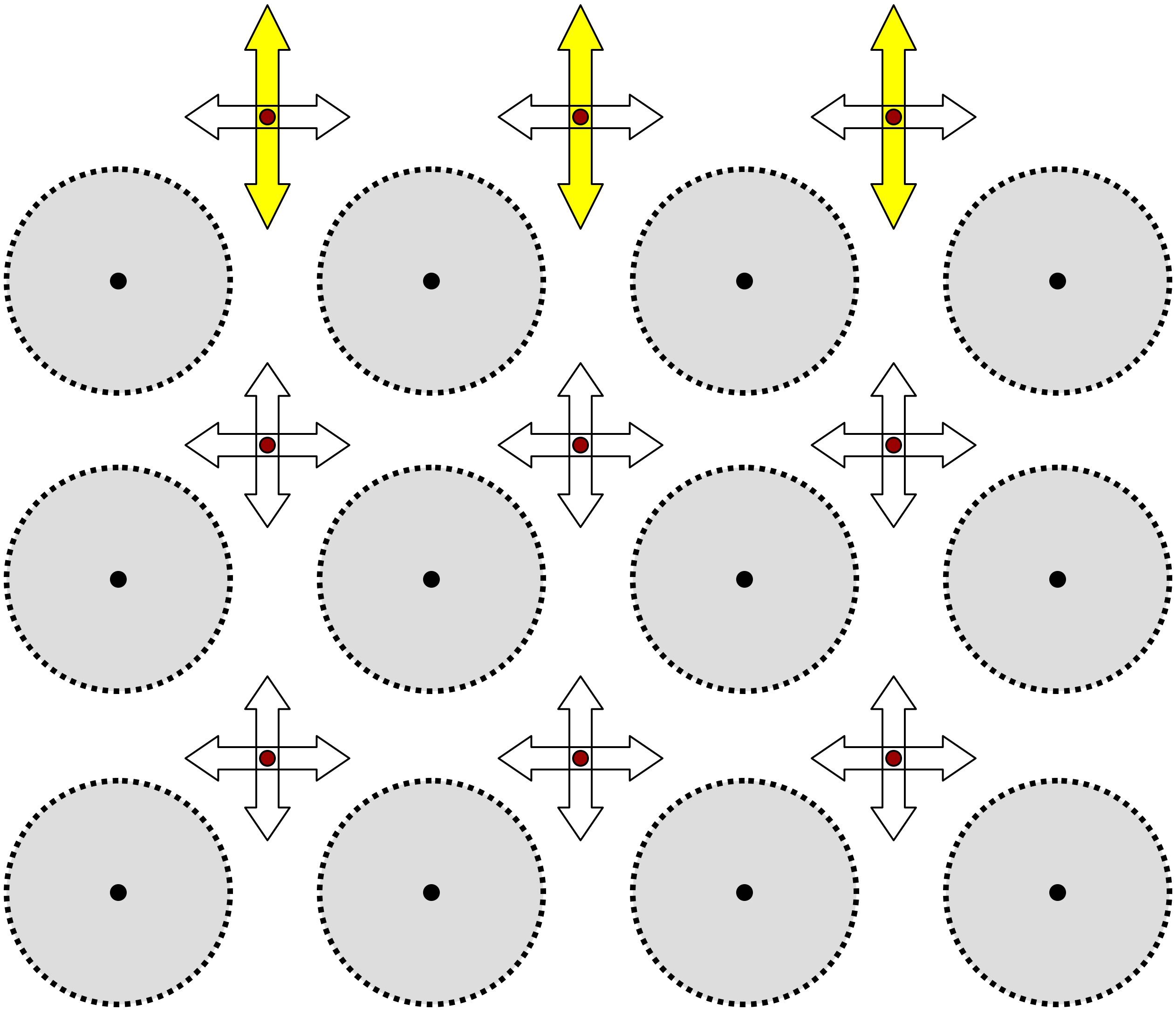
1. H or D at surface of Pd vibrate with large excursions



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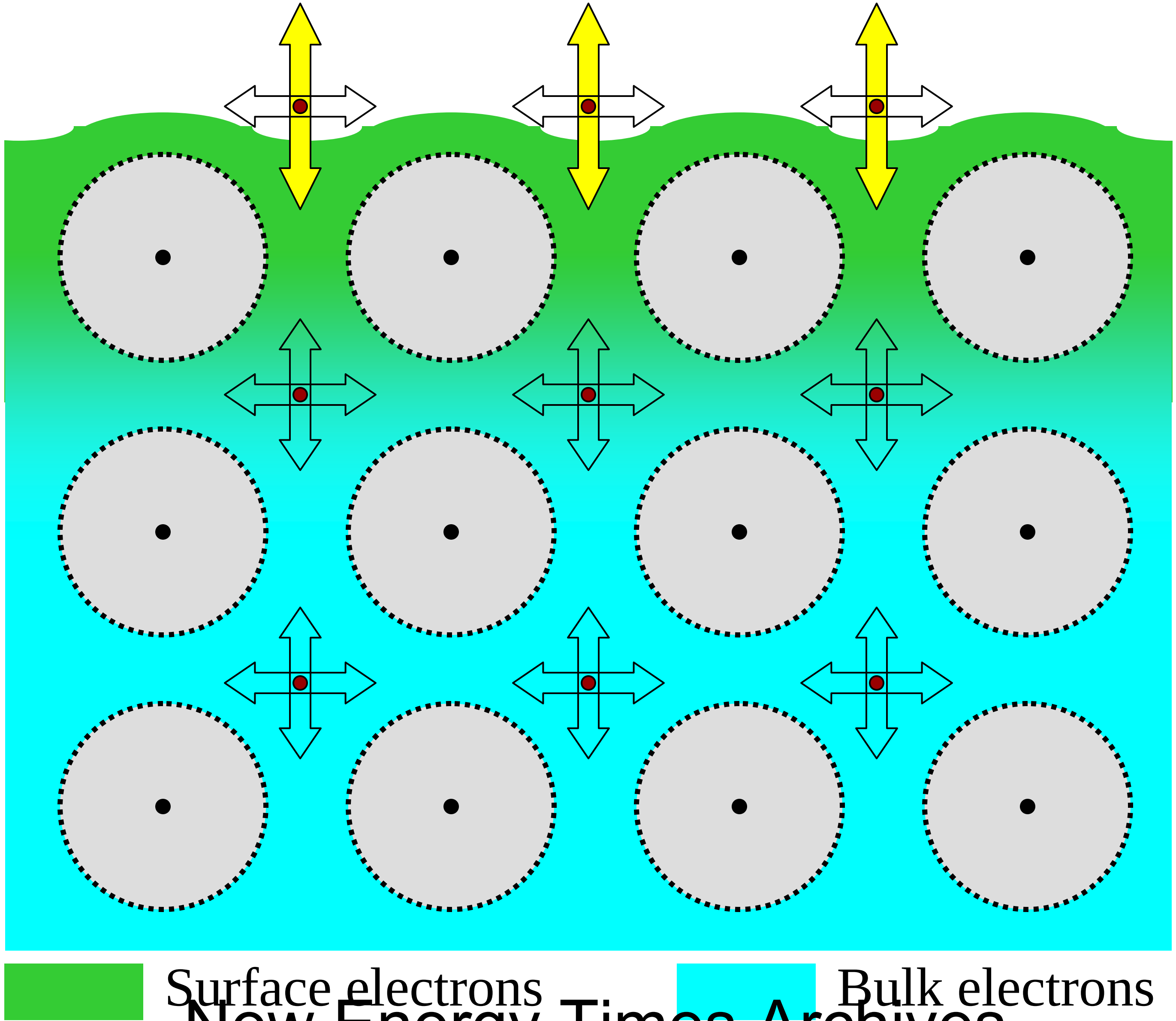
High loading insures H/D population of the surface layer.
Vibrations are thermally driven and temperature dependent.

2. The moving H or D interact with surface plasmons to create strong electromagnetic fields



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2. The moving H or D interact with surface plasmons to create strong electromagnetic fields

$$\mathcal{E} \approx 1.4 \times 10^{11} \text{ volts/meter} \quad \text{(Hydrogen Monolayer)}.$$

$$\sqrt{\overline{|\mathbf{E}|^2}} \approx 6.86 \times 10^{11} (\text{volts/meter}) \sqrt{\frac{\overline{|\mathbf{u}|^2}}{a^2}} \,.$$

$$\sqrt{\frac{\overline{|\mathbf{u}|^2}}{a^2}} \approx 4.2 \quad \text{(Hydrogen Monolayer)}.$$

from neutron scattering data at room temperature

Enhancing the surface plasmon density will increase the electromagnetic field strength.
This may be the basis of increases in excess heat that are observed when a Pd cathode is irradiated with a laser.

3. The EM fields increase the mass ("dress") electrons

$$\tilde{M}_e^2 c^2 = M_e^2 c^2 + \left(\frac{e}{c}\right)^2 \overline{A^\mu A_\mu}$$

A is the vector potential, the derivative of which gives the electromagnetic field strength

$$\beta \equiv \frac{\tilde{M}_e}{M_e} = \left[1 + \left(\frac{e}{M_e c^2}\right)^2 \overline{A^\mu A_\mu}\right]^{1/2}$$

The breakdown[12] of the conventional Born-Oppenheimer approximation for the surface hydrogen atoms contributes to the large magnitude of electromagnetic fluctuations.

[12] J.D. White, J. Chen, D. Matsiev, D.J. Auerbach and A.M. Wadke, *Nature* 433, 503 (2005).

Need a field strength vs mass curve.

4. Heavy electrons (leptons denoted l) and H (or D) react via the weak interaction, producing low momenta (very slow) neutron(s)

$$l^- + p^+ \to n + \nu_l.$$

Coulomb attraction.

Need to satisfy energy (mass) conservation:

For H, the required mass enhancement is

$$M_l c^2 > M_n c^2 - M_p c^2 \approx 1.293\ MeV \approx 2.531\ M_e c^2,$$

For D, the required mass enhancement is

$$\frac{\tilde{M}_e'}{M_e} = \beta'(D \to n + n + \nu_e) > 6.88.$$

Note: The reaction with a deuteron makes two neutrons.

Using neutron scattering data, β = 20.6 for H and D, so the electron mass thresholds for reactions with either H and D are exceeded.

5. The new and slow neutrons react with elements in the experiment

Lithium can be a reactant:

$$
\begin{aligned}
{}^{6}_{3}Li + n &\rightarrow {}^{7}_{3}Li\ , \\
{}^{7}_{3}Li + n &\rightarrow {}^{8}_{3}Li\ , \\
{}^{8}_{3}Li &\rightarrow {}^{8}_{4}Be + e^{-} + \bar{\nu}_e \\
{}^{8}_{4}Be &\rightarrow {}^{4}_{2}He + {}^{4}_{2}He.
\end{aligned}
$$

There is no Coulomb barrier, and this is not D-D fusion

$$Q\{\ {}^{6}_{3}Li + 2n \rightarrow 2\ {}^{4}_{2}He + e^{-} + \bar{\nu}_e\} \approx 26.9\ MeV.$$

$$Q\{\ {}^{6}_{3}Li + n \rightarrow\ {}^{4}_{2}He + {}^{3}_{2}He + e^{-} + \bar{\nu}_e\} \approx 4.29\ MeV.$$

The amounts of excess heat per He produced, and the ratio of He-3 to He-4, both depend on the relative rates of different nuclear reactions.

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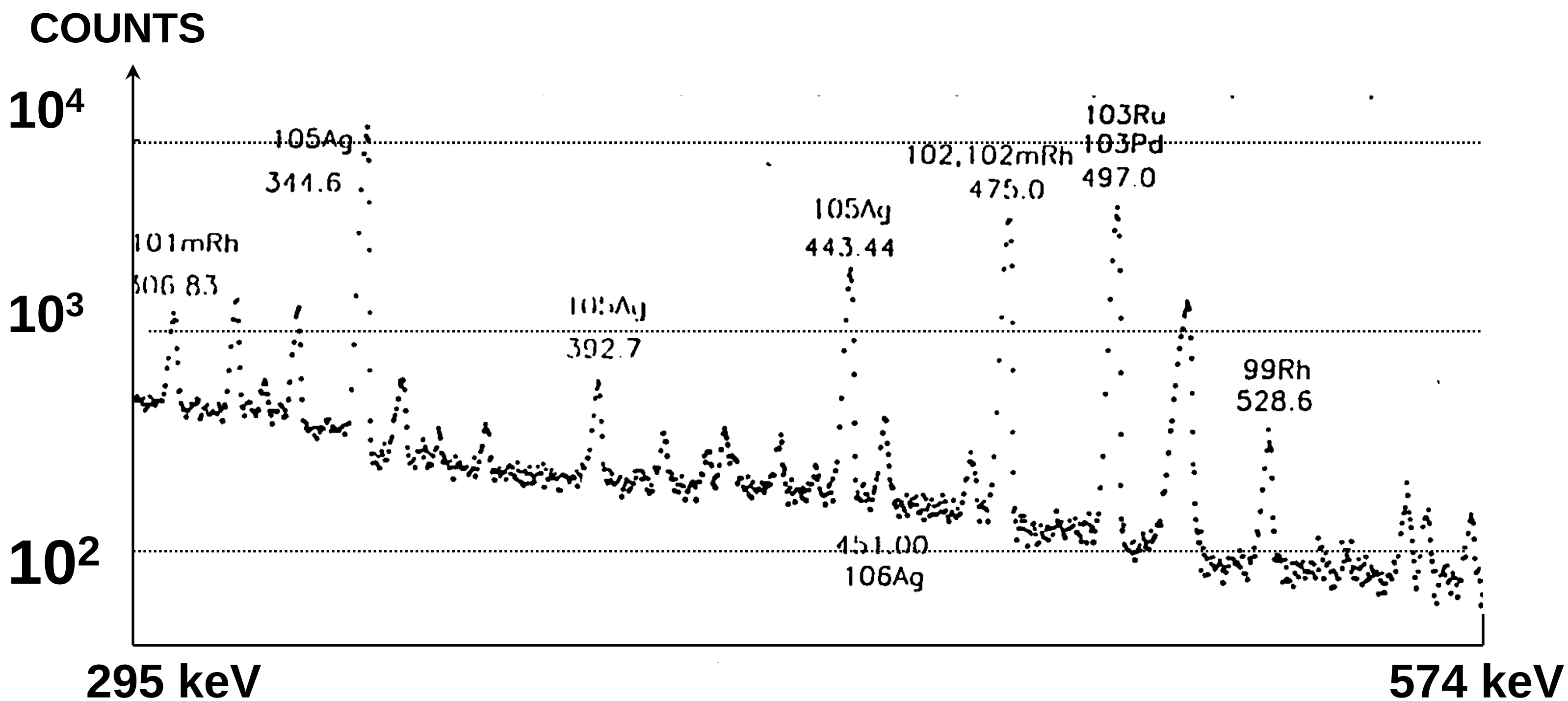
WIDOM & LARSEN INDICATE THAT THEIR THEORY MIGHT BE ABLE TO EXPLAIN THE TRANSMUTATION RESULTS OF IWAMURA et al.

In this regard, ultra low momentum neutrons may produce "neutron rich" nuclei in substantial quantities. These neutrons can yield interesting reaction sequences[17].

[17] Y. Iwamura, M.Sakano and T. Itoh, *Jap. J. Appl. Phys.* 41, 4642 (2002).

CAN THE THEORY OF WIDOM & LARSEN EXPLAIN THE OBSERVATIONS OF WOLF (ASSUMING THEIR VALIDITY)?



STRONG GAMMA-RAY LINES WITH
EXCELLENT SIGNAL-TO-NOISE
PEAKS OCCUR PRECISELY AT
EARLIER TABULATED VALUES OF LINES
FROM ISOTOPES OF Ru, Rh, Pd AND Ag!

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OTHER CHALLENGES TO THE WIDOM & LARSEN THEORY FROM PAST EXPERIMENTS.

Why do H and D produce very different results for Pd cathodes?

Since the theory says that production of excess heat is a near-surface phenomenon, how does excess heat correlate with the area of Pd cathodes in experiments?

Can the theory explain the loading threshold for D and Pd, which is near D/Pd = 0.9, and the quadratic variation of heat production with loading above the threshold?

Can the theory explain current density thresholds, which fall in the range of 100 to 500 mA/cm^2 ?

Is the often-observed need for dis-equilibrium to produce excess heat explicable by enhancement of surface plasmons?