

# Electron Mediated Nuclear Reactions (EMNR)

# Features of the LENR Mechanism to Be Explained

- **LENR:**
  - produce energy in “nuclear amounts” without the huge quanta typical of nuclear reactions,
  - do not produce dangerous neutrons and energetic particles,
  - need hydrogen nuclei,
  - have a strong preference for stable nuclei.
- The Coulomb barrier is somehow overcome.
- LENR affects not only light nuclei, but also heavy ones -> A neutral particle must be involved.

# Constraints for Any LENR Theory

- 27 Years without an Explanation -> **There must be and unexpected physical effect** that affects nuclei, but triggered in “chemical systems”. It should be impossible.
- LENR manifest in many VERY different chemical systems and many skilled chemists struggled to control it -> The effect is most probably not controlled by “chemical parameters”, i.e. it is not related to valence electron orbitals.
- The energy comes from the “force/potential” which keeps nuclei together, i.e. what we call nuclear force.
- The Coulomb barrier between nuclei cannot be overcome kinetically. The consequences would be unmistakable -> The LENR mechanism must somehow be **purely nuclear**.
- The mechanism must prefer stable nuclei.
- The single unexpected physical effect should explain ALL occurrences of LENR (as Edmund Storms always stresses).

# My Uncommon Assumption

Any LENR theory must propose a single unexpected physical effect that contradicts in some way the Standard Model. My choice:

- Nuclei are kept together by the **Magnetic Attraction Mechanism (purely electromagnetic)** proposed by Dallacasa and Cook in the '80. The approach assumes that the magnetic moment of nucleons comes from the rotation of point charges (not from gluons or intrinsic properties of the quarks).

This assumption contradicts a part of the Standard Model which has not been proven (see for example: Martin J. Savage, *Nuclear Forces from Lattice Quantum Chromodynamics*, Presentation at the Int. Conf. on Nuclear Theory in the Supercomputing Era, 2013, Iowa State University, [arXiv:1309.4752](https://arxiv.org/abs/1309.4752).)

The **electron Zitterbewegung** (ZB), which is a very rapid charge rotation, is not different from the internal charge rotation of the nucleons. **So electrons should be attracted to nucleons by the magnetic force that keeps nuclei together. However this should happen only under very special conditions!**

# Magnetic Attraction Mechanism

**Attraction Mechanism Between Nucleons** (by V. Dallacasa and N. Cook):

- The magnetic moment of any particle comes from the rotation of charges. In the simplest case a single charge rotates on a circular orbit at the speed of light. This generates a magnetic field  $B = (\mu_0/4\pi)qv \wedge R/|R|^2$  which varies at the extremely high frequency of the charge rotation.
- When another massive particle is immersed into the previous rapidly oscillating magnetic field, its rotating charge will be subject to the magnetic part of the Lorentz force:  
 $F = q v \wedge B$ .
- **Under very specific conditions** this (oscillating) Lorentz force can generate an average “strong” attraction that overcomes the electrostatic repulsion.

# Necessary Conditions for Magnetic Attraction

The necessary conditions for the magnetic attraction are:

- **Alignment** of the Magnetic Moments (i.e. spin): parallel or anti-parallel.
  - **Rotation Speed**: Synchronous rotation, or alternatively, one frequency should be an integer multiple of the other.
  - **Phase**: zero for parallel magnetic moments and half-cycle for anti-parallel magnetic moments.
- 

## For nucleons (Nuclear Force):

- Protons and neutrons have the same internal charge rotation frequency,
- The necessary phasing (inclusive precession) can be reached only at short distances. This should be the reason for the short range of the nuclear force.

# Zitterbewegung

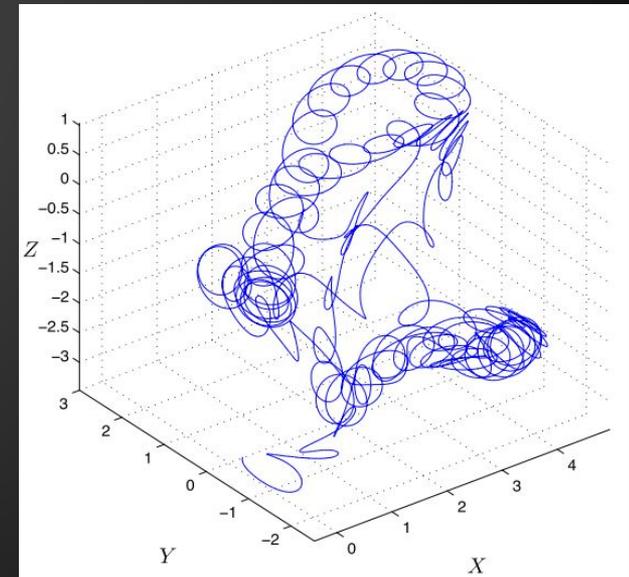
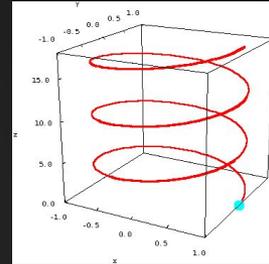
## Electron Zitterbewegung:

- The electron is a point charge with an intrinsic circular rotation component centered along its trajectory.
- The speed of the intrinsic circular motion is  $c$ :
  - Radius  $r_e = 2 m_{\text{mag}} / (gqc) = \hbar / (2m_e c) = 193 \text{ [fm]}$ ,
  - Circular frequency (fixed):  
 $\omega = c / (2\pi r_e) = 2.47 \cdot 10^{20} \text{ [Hz]}$ .

### Comment:

If the speed of the electron (the speed of the centre of the ZB rotation) increases to relativistic values the radius seen by a (relatively) stationary observer shrinks exactly as the relativistic mass increases.

In fact mass and radius are inversely proportional.



# Charge Rotation Inside Nucleons

- Inside nucleons the “rotating” point charges are three (actually QCD speaks about a sea of quarks and gluons) and have two different fractional charges ...
- The simplest simplifying assumption is to consider instead a single charge rotating at the speed of light and at a fixed radius, analogously to the electron case:
  - Rotation radius:  $r = 2 m_{\text{mag}} / (gqc)$
  - Rotation Frequency:  $\omega = c / (2\pi r)$
- In the case of the proton:
  - $r_p = 0.105 \text{ [fm]}$  (much smaller than the charge radius: 0.87 [fm])
  - $\omega_p = 4.54 \cdot 10^{23} \text{ [Hz]}$
- At typical nucleon separation distances (~2 [fm]) the potential of the attractive force obtained with these data is of the same order of magnitude of the nuclear force, i.e. a few [MeV].

# Coupling between Electron and Hydrogen Nucleus

- One necessary condition for the attraction is about the ratio of the two frequencies: one frequency must be an integer multiple of the other.
- Electron and nucleon frequency are quite different:  
 $\nu_p/\nu_e = 1,836.1526\dots$  which is also  $= m_p/m_e$
- So there are two possibilities for the added “orbital” frequency:
  - I. The electron reaches the intrinsic frequency of the proton divided by an integer. The integer giving the smallest energy is 1,836, but others are possible, like 1,837 or 1,835, ...
  - II. The proton reaches the intrinsic frequency of the electron multiplied by an integer. The integer giving the smallest energy is again 1,836, but the neighbouring ones are also possible.
- Condition I. requires a much smaller energy contribution.

# Coupling between Electron and Hydrogen Nucleus

- The lowest orbital frequency contribution for the coupling comes from Condition I and is equal to  $2.055 \cdot 10^{16}$  [Hz].
- The equation defining the coupling frequency is:

$$\Delta_\nu = \left( \frac{v_p}{1,836} \right) - v_\epsilon = v_p \left( \frac{\frac{v_p}{v_\epsilon} - 1,836}{1,836 \frac{v_p}{v_\epsilon}} \right) = 2.055 \cdot 10^{16} [\text{Hz}]$$

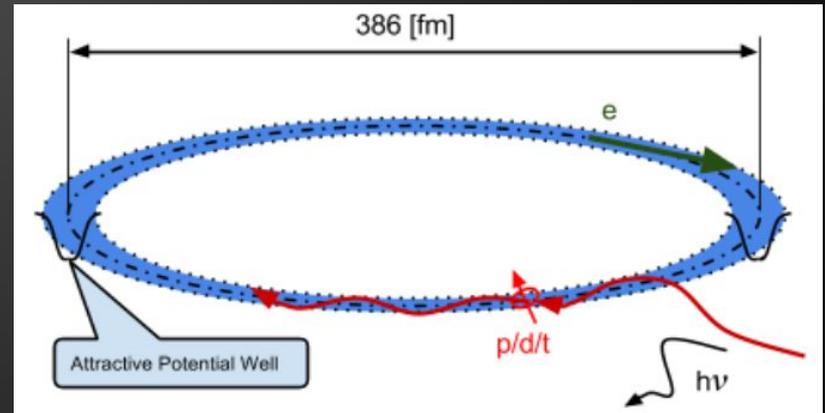
- This frequency corresponds to an energy of  $85$  [eV] and to a wavelength of  $14.6$  [nm], in the Extreme UltraViolet.
- When a proton and an electron see each other rotating at this frequency and the magnetic moments are aligned the coupling should take place.

The energies of the two coupling conditions are shown in the table on the right. Condition I requires energies in the EUV range, while Condition II requires gamma rays.

Coupling Integer	Condition I Energy [eV]	Condition II Energy [keV]
1835	642.0	1,178
<b>1836</b>	<b>85.0</b>	<b>156</b>
1837	471.4	866

# Coupling Between Electron and Hydrogen Nucleus

- If all necessary conditions are satisfied the hydrogen nucleus and the electron feel the *magnetic attractive force* and accelerate towards each other radiating photons in the EUV range (more comments in the next slides).
- The electron has a “diameter” of 386 [fm], therefore it is much larger than nucleons.
- When the approaching hydrogen nucleus crosses the ZB radius the attractive force becomes repulsive.
- So the hydrogen nucleus can be captured by the electron inside its ZB trajectory, like along a racetrack.
- A **Hydronion** (Hyd) has formed.
- Randell L. Mills called it Hydrino, but has nothing to do with a “compact hydrogen”.

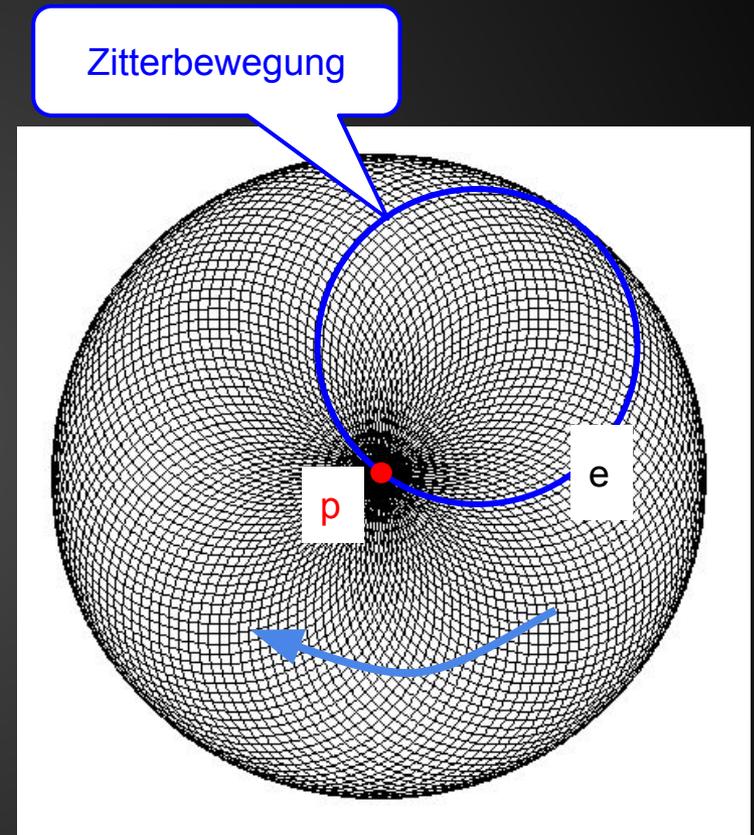


# How Hydronions Look Like

Since the mass of the hydrogen nucleus is much larger than the mass of the electron, the electron trajectory would look more like a circle pinned at the hydrogen nucleus location and “precessing” around it at about  $2.055 \cdot 10^{16}$  [Hz]. It could be defined “spirograph-like”.

The image is clearly not to scale.

**A Hyd is essentially a huge neutral nucleus.**



# Reactions Generating Hydronions



$Gp$ ,  $Gd$  and  $Gt$  are the binding energies of the Hydronions.

Hydronions are neutral and can be attracted towards other nuclei, so that LENR are a two stages process:

- **First Stage:** Generation of Hydronions (it needs a NAE),
- **Second Stage:** The Hyd are captured by other nuclei and host nuclear reactions, continuously perturbed by the point charge of the electron.

The flow of Hyd is the “strange radiation” detected in many LENR experiments.

The second stage is responsible for the metachronous thermal effects and the double optimal operating power of Mitchell Swartz’s Nanor.

# Properties of the Hydronions

- Some of the properties of the Hydronions are:
  - **Neutral charge**,
  - **Large Magnetic Moment**: 960 times that of the neutron,
  - **Large Size**: the area of the Hyd is about 50,000 the section of the neutron,
  - maximum charge displacement vector = 386 [fm], pulsation frequency around  $10^{20}$  [Hz],
  - Binding energy: it should be in the hundreds of [keV] range.
  - **Stable**:
    - Hyd cannot decay into a hydrogen nucleus plus an electron without gamma stimulation,
    - Energetic Hyd could interact with a neutrino and generate a neutron (rare).
    - So Hyd should be stable, and can disappear only after interacting with nuclei.
- Hydronions should travel inside matter more freely than charged particles, and should be able to penetrate electron shells.
- Hyd in condensed matter should be scattered much more intensely than neutrons and some end up trapped in solid lattices (in the locations where the magnetic field gradient is higher).
- **The beta decay of free neutrons should have a small branching fraction producing Hydronions.**

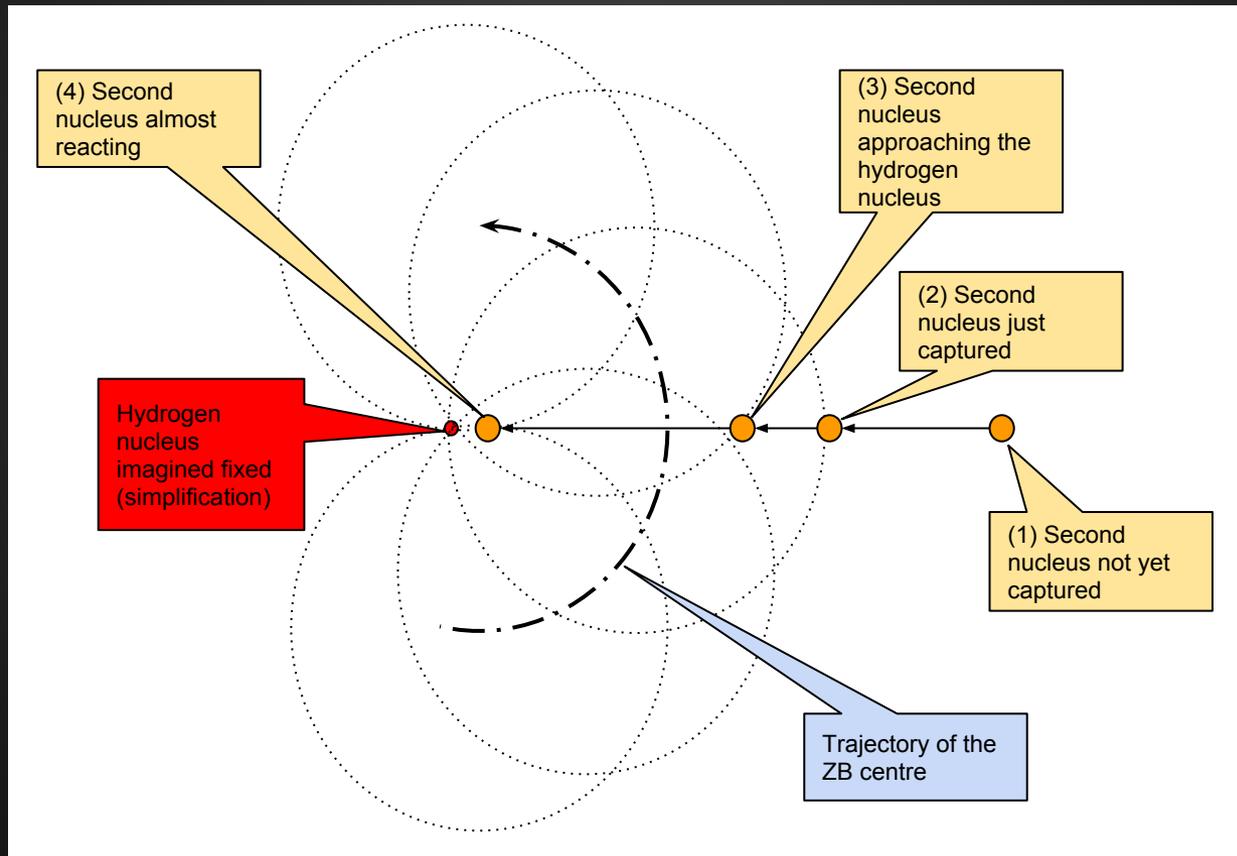
# Phonons and Hydronions

## Effect of Phonons

- In condensed matter Hyd should get trapped relatively easily.
- Phonons, thanks to the spin-phonon coupling, should be able to squeeze the Hyd out of the magnetic traps helping them to react with surrounding nuclei.
- This would explain the effect of phonons on the heat release rate, and qualitatively explain the emissions measured well after the end of the experiments.

# Second Stage Reactions

- Hydronions can capture other nuclei and have them react “inside” the ZB trajectory of the electron.
- This is a simple scheme of the possible “capture” mechanism.



# Types of Second Stage Reactions

In principle these are all the types of **second stage Fusion reactions**:

The electron could participate to the nuclear reaction if its point charge crosses the nuclei while they are reacting. However this entails the weak interaction, which is so slow that the electron should almost never be involved.

The variety of the second stage reactions should be the cause of the many unidentified soft gamma emissions.

**Second Stage Fission reactions**: inside the Hyd are also possible fission reactions.

With Hydronius (ep):			
(p1)	$\text{Nu}(Z, A) + ep \rightarrow \text{Nu}(Z, A+1) + \text{neutrino} + \text{photons}$		
(p2)	$\text{Nu}(Z, A) + ep \rightarrow \text{Nu}(Z+1, A+1) + e + \text{photons}$		
With Deuterionius (ed):			
(d1)	$\text{Nu}(Z, A) + ed \rightarrow \text{Nu}(Z, A+2) + \text{neutrino} + \text{photons}$		
(d2)	$\text{Nu}(Z, A) + ed \rightarrow \text{Nu}(Z+1, A+2) + e + \text{photons}$		
(d3)	$\text{Nu}(Z, A) + ed \rightarrow \text{Nu}(Z, A+1) + ep + \text{photons}$		
? (d4)	$\text{Nu}(Z, A) + ed \rightarrow \text{Nu}(Z+1, A+1) + e + n + \text{photons}$		
With Tritionius (et):			
(t1)	$\text{Nu}(Z, A) + et \rightarrow \text{Nu}(Z, A+3) + \text{neutrino} + \text{photons}$		
(t2)	$\text{Nu}(Z, A) + et \rightarrow \text{Nu}(Z+1, A+2) + e + \text{photons}$		
(t3)	$\text{Nu}(Z, A) + et \rightarrow \text{Nu}(Z, A+2) + ep + \text{photons}$		
(t4)	$\text{Nu}(Z, A) + et \rightarrow \text{Nu}(Z, A+1) + ed + \text{photons}$		
? (t5)	$\text{Nu}(Z, A) + et \rightarrow \text{Nu}(Z+1, A+1) + e + 2n + \text{photons}$		

# Second Stage Reactions: Hydrogen Isotopes Only

When Hyd meet hydrogen nuclei, all the possible reactions are these:

1e : p+ep	->d + neutrino + (max)	1.442 [MeV] - Gp
2e : p+ed	-> <b>t</b> + neutrino + (max)	5.475 [MeV] - Gd
3e : d+ep	-> <b>t</b> + neutrino + (max)	5.475 [MeV] - Gp
3 : d+ep	-> <b>He3</b> + e +	4.472 [MeV] - Gp
4e: d+ed+0.141 [MeV]+Gd->H4 + neutrino +		0.00 [MeV]
	H4 -> <b>t</b> + <b>n</b> +	3.391 [MeV]
4.1: d+ed	-> <b>He4</b> + e +	22.825 [MeV] - Gd
4.2: d+ed	-> <b>t</b> + ep +	4.033 [MeV] - Gd + Gp
5e : <b>t</b> +ep+4.174 [MeV]+Gp->H4 + neutrino +		0.00 [MeV]
	H4 -> <b>t</b> + <b>n</b> +	3.391 [MeV]
5 : <b>t</b> +ep	-> <b>He4</b> + e +	18.792 [MeV] - Gp
6e : <b>t</b> +ed+5.318 [MeV]+Gd->H5 + neutrino +		0.00 [MeV]
	H5 -> <b>t</b> + 2 <b>n</b> +	2.311 [MeV]
6.1: <b>t</b> +ed	->He5 + e +	15.832 [MeV] - Gd
	He5 -> <b>He4</b> + <b>n</b> +	0.735 [MeV]
6.2: <b>t</b> +ed+5.616 [MeV]+Gd->H4 + ep		0.00 [MeV] + Gp
	H4 -> <b>t</b> + <b>n</b> +	3.391 [MeV]

The reactions producing neutrons are endothermic.

When 4He is produced there is a large energy release.

7 : <b>t</b> (beta decay)	-> <b>He3</b> + e + antineut. + (aver)	5.7 [KeV]
8e : <b>He3</b> +ep	-> <b>He4</b> + neutrino + (max)	19.80 [MeV]
9 : <b>He3</b> +ed	-> <b>He4</b> + ep + (max)	20.58 [MeV]

# Hydronions react with Hydrogen Nuclei, Only Stable Products and no Weak Interaction

All reactions which produce neutrinos should be kinetically very slow because the weak interaction is much slower than the other interactions.

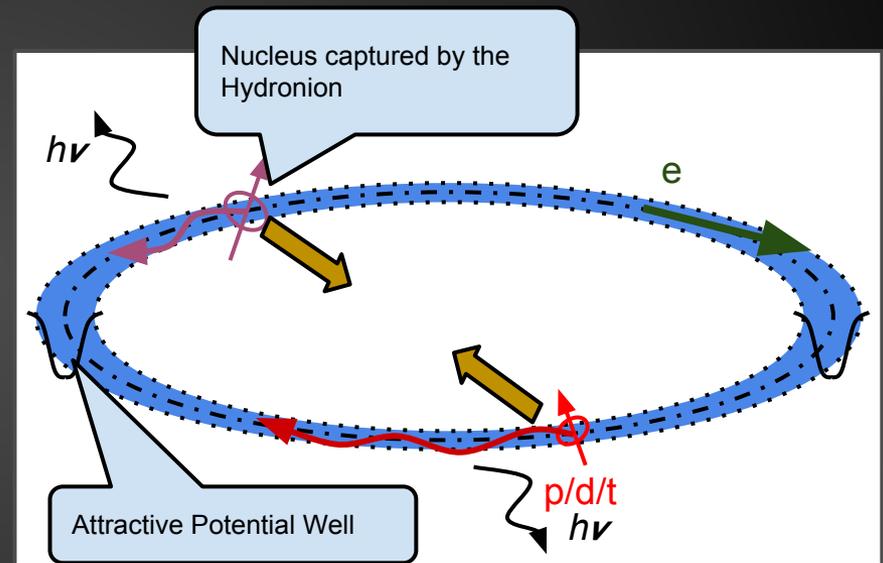
Some reactions are energy-controlled (endothermic).

Probably tritium is sufficiently stable to be actually produced, but only in very small quantities. And reactions 5 and 6.1 can eliminate it readily.

1e	: p+ep	----->d	+ neutrino	+ (max)	-----1.442[MeV]	- Gp
2e	: p+ted	----->t	+ neutrino	+ (max)	-----5.475[MeV]	- Gd
3e	: d+ep	----->t	+ neutrino	+ (max)	-----5.475[MeV]	- Gp
3	: d+ep		-> He3	+ e +	4.472 [MeV]	- Gp
4e	: d+ted	+0.141[MeV]+Gd	->H4	+ neutrino	+ 0.00 [MeV]	
			H4	->t	+ n	+ 3.391[MeV]
4.1	: d+ted		-> He4	+ e +	22.825 [MeV]	- Gd
4.2	: d+ted		->t	+ ep +	4.033 [MeV]	- Gd + Gp
5e	: t+ep	+4.174[MeV]+Gp	->H4	+ neutrino	+ 0.00 [MeV]	
			H4	->t	+ n	+ 3.391[MeV]
5	: t+ep		-> He4	+ e +	18.792 [MeV]	- Gp
6e	: t+ted	+5.318[MeV]+Gd	->H5	+ neutrino	+ 0.00 [MeV]	
			H5	->t	+ 2n	+ 2.311[MeV]
6.1	: t+ted		-> He4	+ n + e +	16.567 [MeV]	- Gd
6.2	: t+ted	+5.616[MeV]+Gd	->H4	+ ep	+ 0.00 [MeV]	+ Gp
			H4	->t	+ n	+ 3.391[MeV]
7	: t(beta decay)		-> He3	+ e + antineut.	+ (aver) 5.7 [KeV]	
8e	: He3+ep		-> He4	+ neutrino	+ (max) 19.80 [MeV]	- Gd + Gp
9	: He3+ted		-> He4	+ ep	+ (max) 20.58 [MeV]	

# Preference for Stable Nuclides

The point charge of the electron crosses any forming nucleus along its ZB about  $2.47 \cdot 10^{20}$  times per second, and remains always within 386 [fm], therefore it perturbs continuously the forming nuclei and prevents their assembly (a sort of forced decay) if they are not stable enough. So only the most stable nuclear configurations (certain lattices) can survive.



# Second Stage with Hydrogen

The reactions taking place at a significant rate between Hyd and hydrogen nuclei are these:

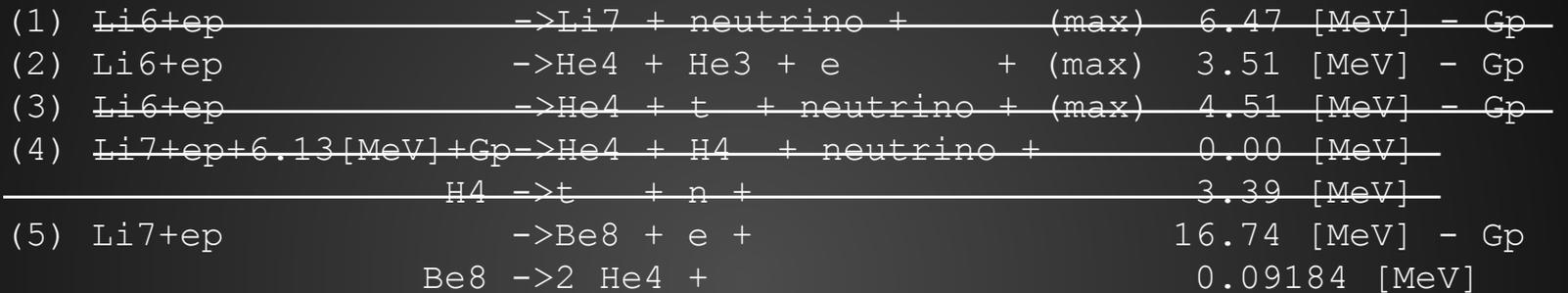
3	: d+ep	-> He3 + e +	4.472 [MeV] - Gp
4.1:	d+ed	-> He4 + e +	22.825 [MeV] - Gd
4.2:	d+ed	-> t + ep +	4.033 [MeV] - Gd + Gp
5	: t+ep	-> He4 + e +	18.792 [MeV] - Gp
6.1:	t+ed	-> He4 + n + e +	16.567 [MeV] - Gd
7	: t(beta decay)	-> He3 + e + antineut. +	(aver) 5.7 [KeV]
9	: He3+ed	-> He4 + ep +	(max) 20.58 [MeV]

- **Loading with protium:**
  - there are no second stage reactions with hydrogen nuclei, but only isotopic shifts and (“stable”) fissions.
- **Loading with deuterium:**
  - It is possible to produce He4, which liberates a lot of energy, but this causes a very localized (and problematic) power release,
  - There can be neutron production (through reaction 6.1), but only when tritium is abundant.
- Both types of loading allow to eliminate tritium. However with deuterium the elimination of tritium produces free neutrons.

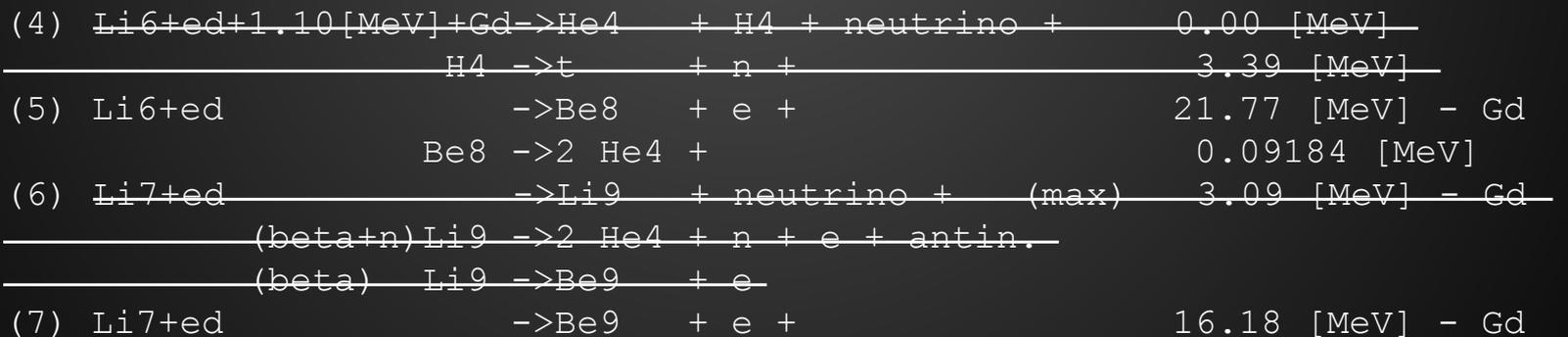
# Second Stage Reactions with Lithium

The Second Stage reactions involving Lithium are:

- For Hydronius:

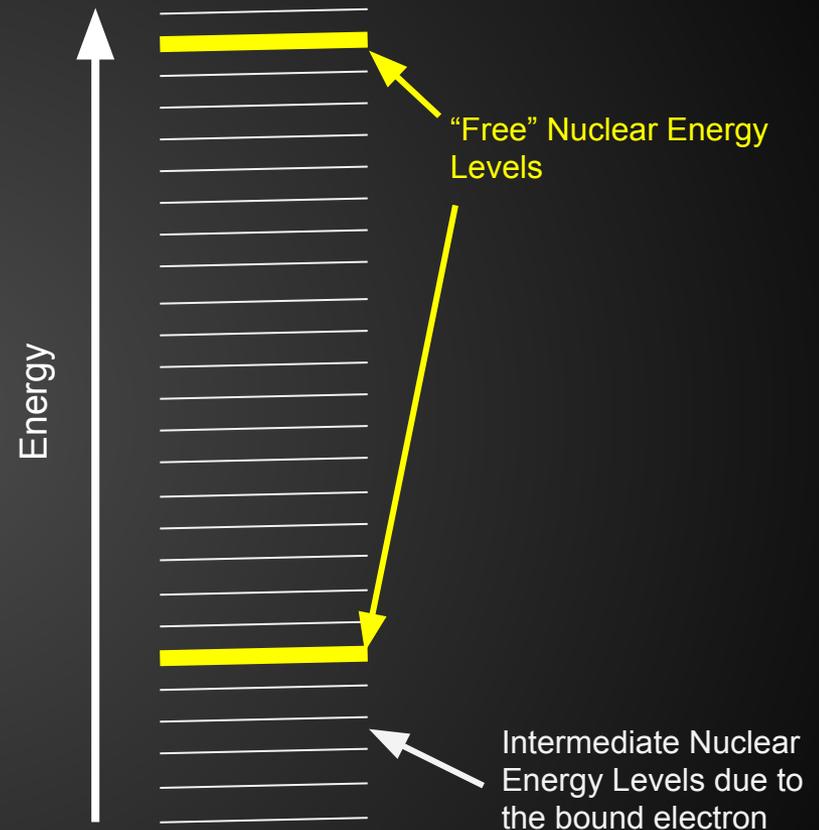


- For Deuteronius:



# Intermediate Nuclear Energy Levels?

- The absence of substantial amounts of prompt gamma radiation from LENR experiments suggests the existence of a fractionation mechanism for the Second Stage reactions.
- The presence of the electron could generate a series of many (unstable) states energetically in-between the known “free” nuclear states.
- The typical energy distance between nuclear states is one [MeV], while the distance between the intermediate states could be in the EUV/soft-X range.



# Emissions of EMNR

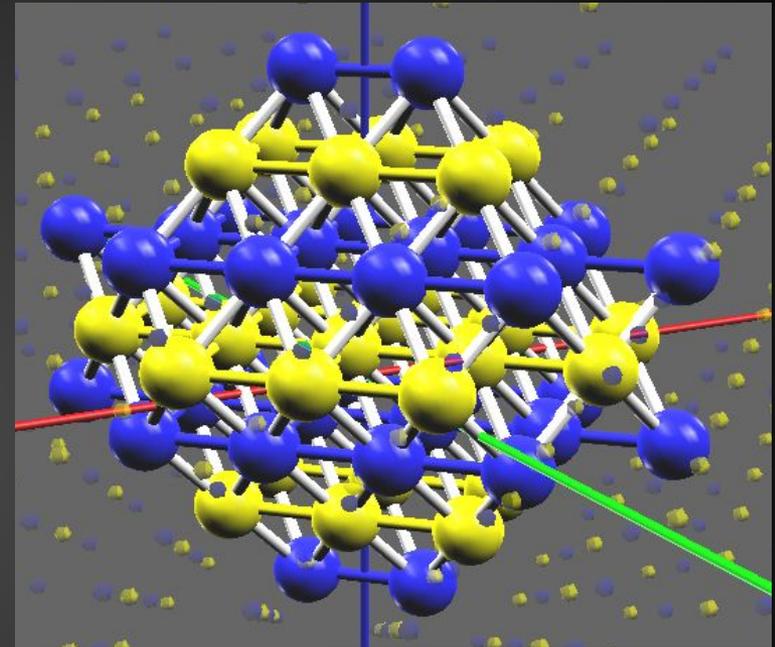
- **First Stage** (Hyd formation) reactions emit:
  - Intense Extreme Ultraviolet,
  - Soft X ray: the electrons that form the Hyd are taken from core orbitals and, when they disappear, cause electron shell rearrangements,
  - A few Auger electrons.
- **Second Stage** reactions (nuclear fusion and fission inside the Hyd) emit:
  - Mostly EUV/soft X,
  - In some cases there could be gamma in the [MeV] range, when fractionation does not take place,
  - Beta emission from any produced the beta emitter.

# Non-Reacting Nuclei

Some nuclei should not react at all with the Hyd because they lack any magnetic moment.

An example: Ni62

- It has the highest binding energy per nucleon. The reason must be a high symmetry. This high symmetry causes the absence of magnetic moments -> No coupling.
- Moreover with Ni62 there are neither fusion (or isotopic shifts) nor fissions that can liberate energy.

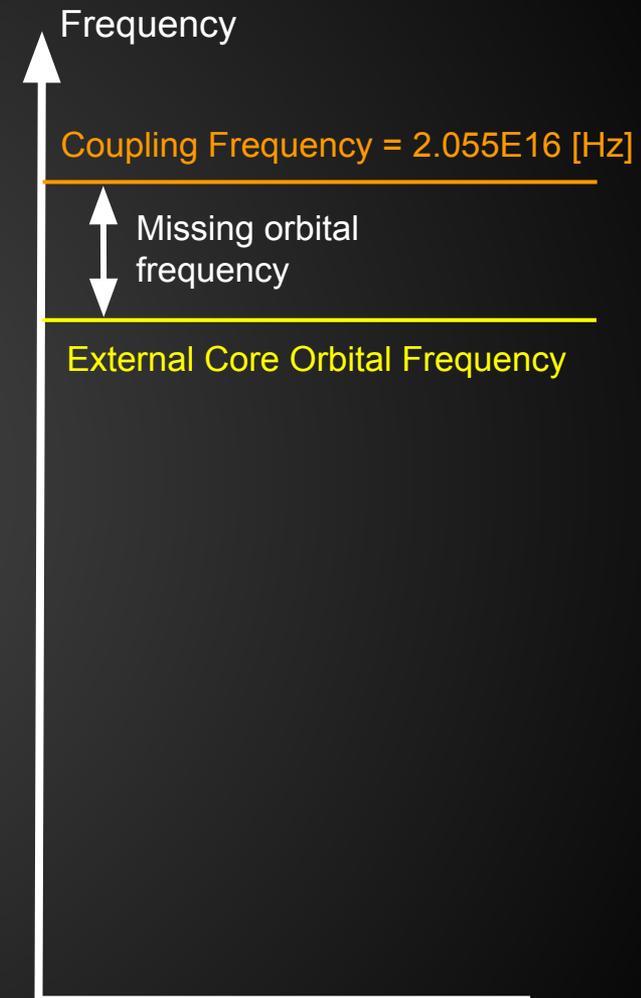


The possible symmetric structure of Ni62. The drawing was prepared through the QND Software of Norman Cook: <http://www.res.kutc.kansai-u.ac.jp/~cook/40%20NVSDownload.html>

# The Nuclear Active Environment (NAE)

The most important bit of any LENR theory is the Nuclear Active Environment:

- The lowest orbital frequency contribution necessary for coupling (to be added to the intrinsic electron frequency offered by atomic orbitals) is  $2.055 \cdot 10^{16}$  [Hz]; corresponding to an energy of 85 [eV].
- Valence orbitals never reach this energy.
- If an “external” core orbital that has a energy near to 85 [eV] is stricken by a hydrogen nucleus with the correct energy the coupling can take place.
- Only rarely such energetic orbitals are “exposed” to incoming hydrogen nuclei;
- Ionic bonds are good at exposing underlying energetic core orbitals.

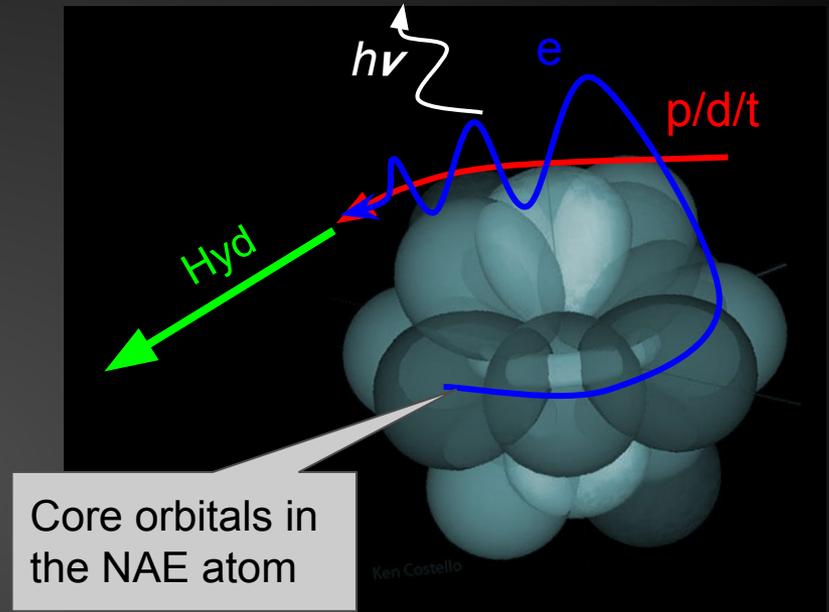


# The Nuclear Active Environment in a Picture

When the electron in the External Core Orbital and the striking proton see each other “rotating” at a coupling frequency, they start to attract each other.

The coupling happens only at a specific frequency; so, as the freed electron approaches the hydrogen nucleus, it spirals towards it at a constant frequency. As the distance to the nucleus decreases the electron emits energy in the form of EUV near to the coupling wavelength and energy (14.6 [nm], 85 [eV]).

The energy necessary for extracting the electron from the core orbital (its chemical binding energy) is provided by the magnetic attraction potential.

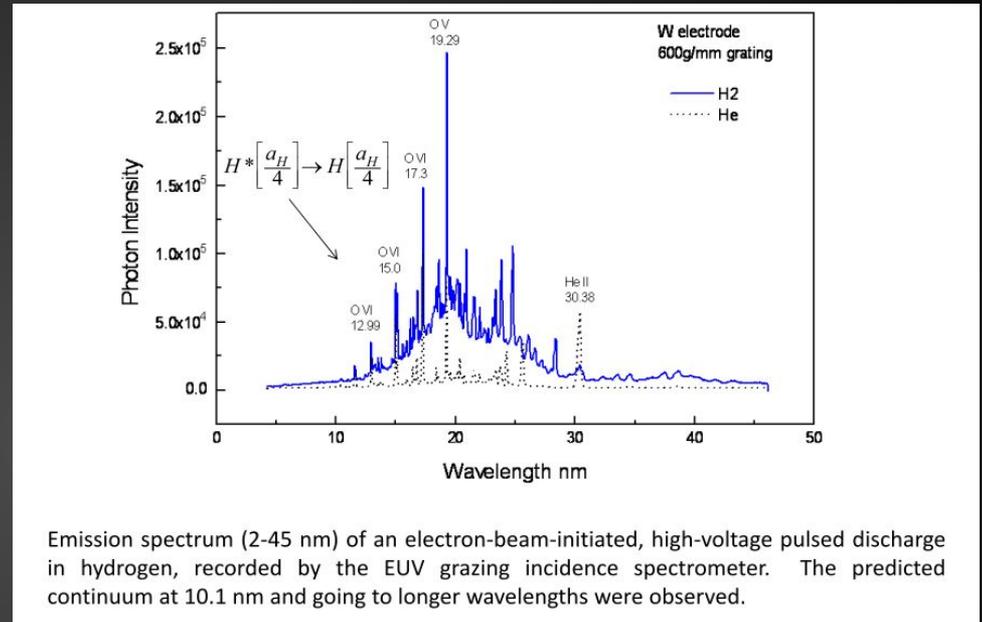


# Extreme Ultraviolet Emissions Measured by Randell Mills

Randell Mills measured a large excess in EUV emissions from his plasmas.

In the case on the right the EUV power can be fitted with a Cauchy distribution with a peak at about 64.5[eV] (19.2[nm] wavelength) and a  $\Gamma$  broadening of about 12[eV].

$$I(E) = \frac{(\Gamma/2)^2}{(E - E_0)^2 + (\Gamma/2)^2}$$



Interpreting the results through the EMNR theory, it appears that Mills is using Potassium as Nuclear Active Environment, the same used by Holmlid.

The NAE of the EMNR is explained in the next slides.

# The Nuclear Active Environment

- The NAE is the combination of:
  - An External Core Orbital (ECO), that has an energy near to the coupling energy, and
  - A hydrogen nucleus which strikes the ECO with the right energy.
- The naked ECO can be found in solids, liquids or plasmas. In condensed matter the ECO becomes particularly exposed when there are ionic bonds.
- The NAE depends on something that has no role in chemistry: the ECO. Therefore many totally different chemical systems can offer a NAE.
- The rarity of the NAE is essentially due to two factors:
  - It is not common to have hydrogen nuclei striking the naked ECO with the right energy,
  - even when that happens the density of the first stage reactions is so low that there is no appreciable macroscopic effect.
- In the experiments of Iwamura the NAE is in the  $\text{CaO}_2$  (or other oxides) layers.
- The energy to be given to the hydrogen nuclei depends on the energy of the naked ECO; Ca requires an energy contribution from the hydrogen of less than 1[eV] (see [this slide](#) for the list of the best atoms or the NAE).

# Which are the Best NAE?

The minimum coupling happens at an orbital energy of 85[eV], which is below any binding orbital: outside the the domain of chemistry and physical-chemistry.

The ECO are minimally influenced by chemical bonds. So the ionization energies of atoms (valid for free ions) should not be too far from the actual ECO energies of atoms bound in a chemical structure. In particular ionic bonds should be the best bonds to expose the ECOs.

So it is possible to look at the ionization energies of all atoms in search for the orbitals which lie nearest to the coupling.

The table in the next slide lists the best orbitals (ionization) energies which are nearest to the coupling. The data comes from the **NIST database**. It is important to note that **many energy values are only calculations, not actual measurements**.

The column “Diff. to Coupling” shows the difference between the ionization energy and the coupling energy 85[eV]. So this column corresponds to the missing energy to reach the coupling. The column “Abs. Diff.” shows the absolute value of the energy difference, and has been used to order the orbitals (and their corresponding atoms).

# Ionization Energies and Coupling (NIST Data)

A series of messages can be taken from the list:

- The orbital with exactly the coupling energy belongs to an atom (nucleus) that is not stable: Pr135 decays by Electron Capture.
- The second best orbital belongs to Osmium (its energy is only theoretical). NaOsO<sub>3</sub> (perovskite) has [the strongest spin-phonon coupling ever measured](#).
- The 5<sup>th</sup> orbital of Ca lies at less than an [eV] from the coupling. Is Iwamura using this orbital?
- The 6<sup>th</sup> orbital of Palladium is at less than an [eV] from the coupling. Is this the reason for the success of the numerous experiments using Pd?
- The best orbital appears to be the 5<sup>th</sup> of Zr, which is very well exposed in common Zr oxides. Mitchell Swartz and others in fact use it.
- The third orbital of Mg should be fine as well. However Iwamura says it does not work; but his hydrogen nuclei have very low energies (diffusion energy only).
- Li is a good option, while it requires a higher energy contribution from hydrogen (electrochemical or “plasma”). Rossi, Lipinsky, electrochemistry, ...
- The fourth orbital of N should be also interesting: is this part of the secret of blue Palladium?

Atomic Number	Spectrum Name	Ion Charge	El. Name	Ionization Energy (eV)	Diff. To Coupling	Abs. Diff.
61	Pm VI	5	Promethium	85	-0.02	0.02
76	Os VII	6	Osmium	85.1	-0.12	0.12
20	Ca V	4	Calcium	84.34	0.64	0.64
46	Pd VI	5	Palladium	84.1	0.88	0.88
60	Nd VI	5	Neodymium	84	0.98	0.98
56	Ba VII	6	Barium	86	-1.02	1.02
31	Ga V	4	Gallium	86.01	-1.03	1.03
48	Cd VI	5	Cadmium	87	-2.02	2.02
37	Rb VI	5	Rubidium	82.9	2.08	2.08
55	Cs VII	6	Cesium	82.9	2.08	2.08
82	Pb VI	5	Lead	82.9	2.08	2.08
9	F IV	3	Fluorine	87.18	-2.2	2.2
75	Re VII	6	Rhenium	82.71	2.27	2.27
19	K V	4	Potassium	82.66	2.32	2.32
30	Zn V	4	Zinc	82.6	2.38	2.38
35	Br VI	5	Bromine	87.39	-2.41	2.41
53	I VII	6	Iodine	87.61	-2.63	2.63
47	Ag VI	5	Silver	82	2.98	2.98
59	Pr VI	5	Praseodymium	82	2.98	2.98
38	Sr VI	5	Strontium	88	-3.02	3.02
43	Tc VII	6	Technetium	88	-3.02	3.02
57	La VII	6	Lanthanum	88	-3.02	3.02
63	Eu VI	5	Europium	88	-3.02	3.02
16	S VI	5	Sulfur	88.05	-3.07	3.07
34	Se VI	5	Selenium	81.83	3.15	3.15
83	Bi VI	5	Bismuth	88.4	-3.42	3.42
64	Gd VI	5	Gadolinium	89	-4.02	4.02
77	Ir VII	6	Iridium	89	-4.02	4.02
40	Zr V	4	Zirconium	80.35	4.63	4.63
12	Mg III	2	Magnesium	80.14	4.84	4.84
45	Rh VI	5	Rhodium	80	4.98	4.98
81	Tl VI	5	Thallium	80	4.98	4.98
49	In VI	5	Indium	90	-5.02	5.02
62	Sm VI	5	Samarium	90	-5.02	5.02
65	Tb VI	5	Terbium	90	-5.02	5.02
29	Cu V	4	Copper	79.8	5.18	5.18
27	Co V	4	Cobalt	79.5	5.48	5.48
32	Ge V	4	Germanium	90.5	-5.52	5.52
24	Cr VI	5	Chromium	90.64	-5.66	5.66
58	Ce VII	6	Cerium	91	-6.02	6.02
78	Pt VII	6	Platinum	91	-6.02	6.02
18	Ar VI	5	Argon	91.29	-6.31	6.31
39	Y VI	5	Yttrium	91.39	-6.41	6.41
36	Kr VI	5	Krypton	78.49	6.49	6.49
54	Xe VII	6	Xenon	91.6	-6.62	6.62
21	Sc V	4	Scandium	91.95	-6.97	6.97
58	Ce VI	5	Cerium	77.6	7.38	7.38
7	N IV	3	Nitrogen	77.47	7.51	7.51
8	O IV	3	Oxygen	77.41	7.57	7.57
50	Sn V	4	Tin	77.03	7.95	7.95
44	Ru VII	6	Ruthenium	93	-8.02	8.02
66	Dy VI	5	Dysprosium	93	-8.02	8.02
80	Hg VII	6	Mercury	93	-8.02	8.02
80	Hg VI	5	Mercury	76.6	8.38	8.38
28	Ni V	4	Nickel	76.06	8.92	8.92
44	Ru VI	5	Ruthenium	76	8.98	8.98
50	Sn VI	5	Tin	94	-9.02	9.02
79	Au VII	6	Gold	94	-9.02	9.02
73	Ta VI	5	Tantalum	94.01	-9.03	9.03
3	Li II	1	Lithium	75.64	9.34	9.34
26	Fe V	4	Iron	75	9.98	9.98
78	Pt VI	5	Platinum	75	9.98	9.98
39	Y V	4	Yttrium	74.97	10.01	10.01

# NAE Orbitals and Superconductivity at High Temperature

Many of the atoms having good NAE-orbitals are also used in High Temperature Superconductors; they are marked with reddish dots ( ● ) near their names in the table:

- Ca, Ba, Sr, La, S, Se, Bi, Mg, Rh, Tl, Cu, ...

Some ECO of these atoms could react strongly to phonons (nearby nuclei) and make the metallic orbitals “breath” together with the lattice.

Are these NAE-orbitals involved in the unusually strong phonon-electron coupling necessary for a high temperature BCS?

- [A recent \(2016\) publication on Physical Review Letters](#) shows that static, as opposed to fluctuating, charge stripes coexist with superconductivity in a cuprate when lanthanum and barium are added in certain amounts
- [A recent \(2016\) publication on Science](#) suggests that “nuclear effects help bring about superconductivity in ytterbium dirhodium disilicide (YRS)”; confirming the role of the nuclear spin in SC.
- [Another recent publication \(2016\) on Nature Communications](#) suggests that “magnetic fluctuations in magnetically disordered compounds ... appear to be essential for superconductivity”; the spin-exciton and the paramagnon mechanisms could be two ends of a continuum.

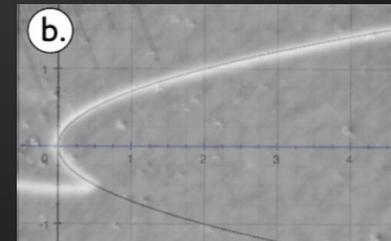
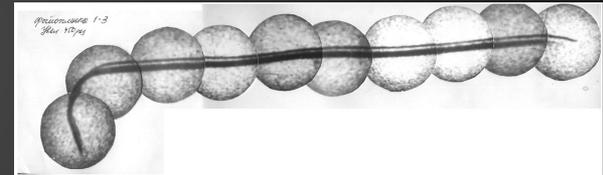
# Hydronions Radiation

A number of experimentalists noticed an unexplainable neutral radiation:

- Transmutations far from the reaction sites,
- Traces of strange particles on nuclear emulsions, appearing hours after the energetic events.

The traces have unique features and can not be explained by known particles:

- The particle is neutral (no delta electrons),
- There is periodicity [ $\mu\text{m}$ ] range,
- Parabolic trajectories in magnetic fields,
- ...



# Periodic Traces from Precessing Hydronions

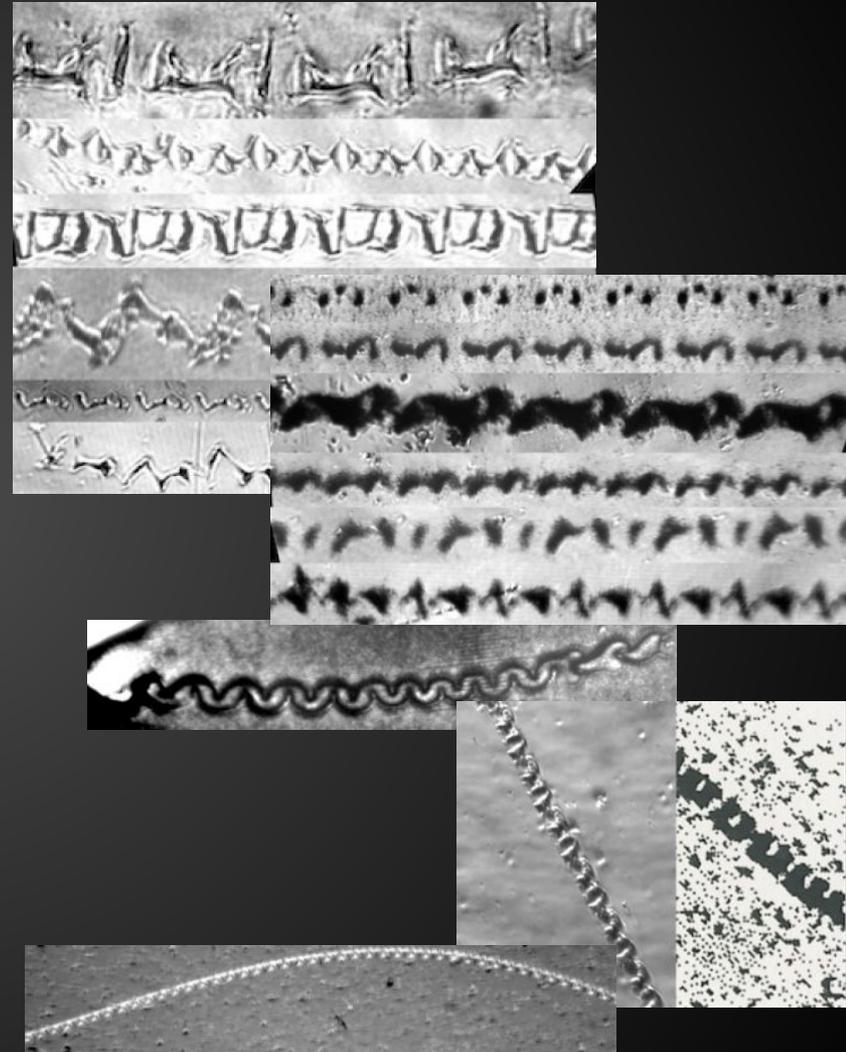
A simple check of the orders of magnitude:

- Since trapped Hyd are emitted by “phonon-magnetic” waves, their speeds should be in the range of 1000 [m/s].
- The structure of the Hydronions suggests that the electron ZB trajectory should precede at radio frequencies with magnetic fields of a fraction of Gauss. This agrees with the measured RF emissions.

Let us assume a precession frequency of 10 [MHz].

If a Hyd precedes at 100 [MHz], and has a speed of 1000 [m/s], the spatial pitch of its trace would be **10 [μm]**.

This agrees with the measured pitch of the traces.

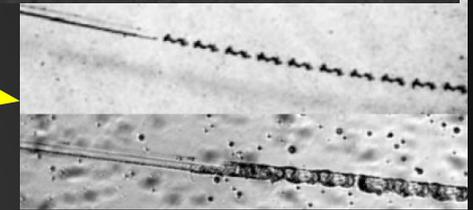


# More on Inexplicable Traces

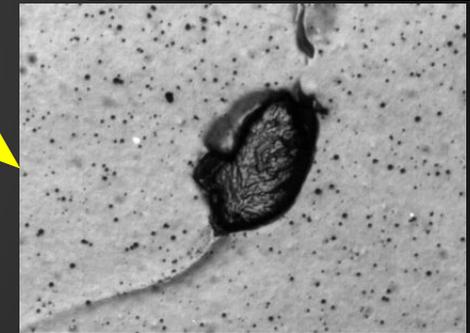
The **random motion** seen in some cases is probably due to low momentum that allows a relatively intense scattering.



The **sudden change from a saturated track to a periodic track** depends on the RF encountered by the Hyd on its path.

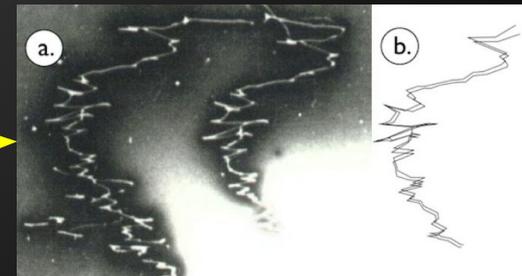


**Traces end abruptly at a burnt spot:** the Hyd couples to a nucleus on its path and caused a nuclear reaction with the consequent dense energy emission that causes the burn.



The **progressive thinning of the traces** follows the relaxation of the precession due to RF emissions while the Hyd travel.

In some cases a phonon can cause the ejection of two or more Hyd at the same time from nearby sites and with the same spin orientation. The timing and the spin orientation match should be fairly precise if the emitted Hyd were trapped in identical types of traps in the lattice. Since Hyd react only to magnetic field variations and radio waves, the emitted Hyd will **travel in a way that looks entangled** because they feel the same RF and the same magnetic fields.

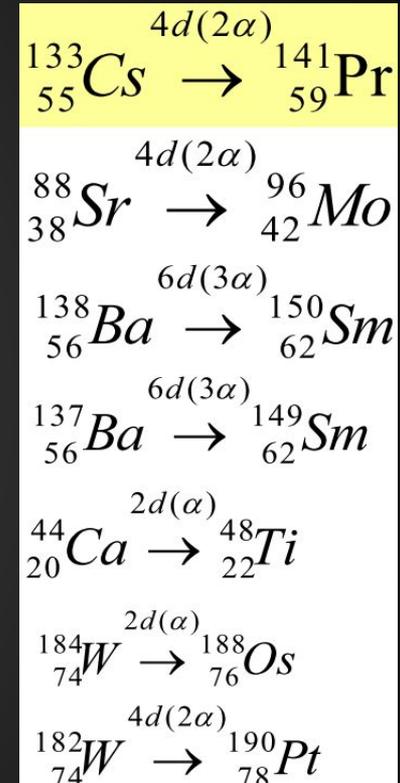


# Some Comments on Iwamura's Results

Iwamura uses CaO layers. The 5<sup>th</sup> orbital of Ca and the 6<sup>th</sup> orbital of Pd are two of the nearest to the coupling (both at less than 0.65 [eV]). This allows Iwamura to stimulate by diffusion only and:

- produce Deuteronium, which travels through the Pd and CaO layers;
- some Hyd reach the surface where new atoms (X) have been deposited.
- A Deuteronium can be captured by an X nucleus.
- A second deuteronium can deposit a deuteron inside the first deuteronium ZB; so there can be accumulation of deuterons inside a Hyd.

When the X nucleus and the accumulated deuterons can originate a new stable nucleus the reaction takes place. In some cases there are fissions as well.



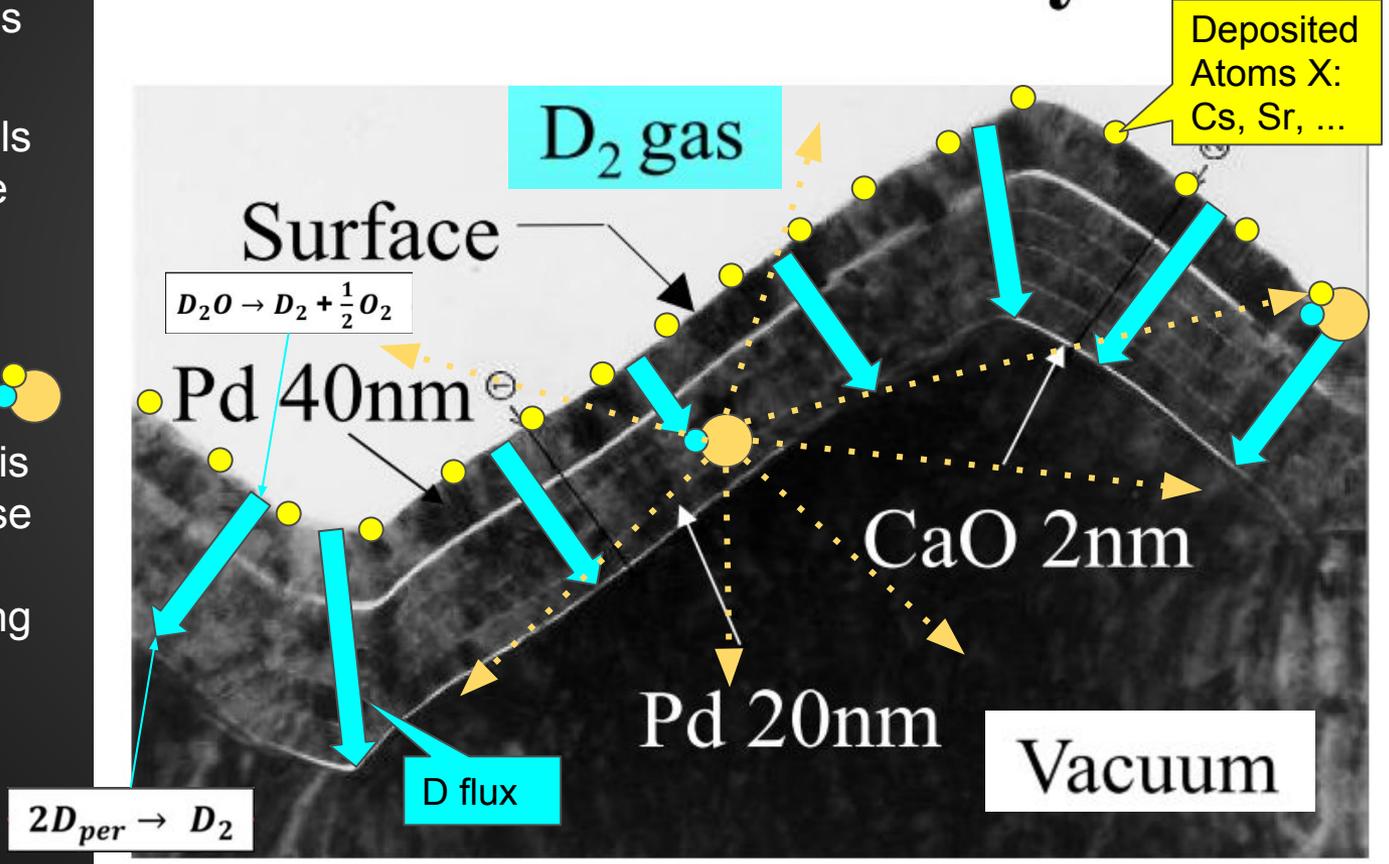
# Some Comments on Iwamura's Results

D travels through the layers and, by encountering Ca forms Deuteronium: 

The neutral Hyd travels in all directions. Some reach the seeded surface and couple to the nuclei of the deposited atoms X: 

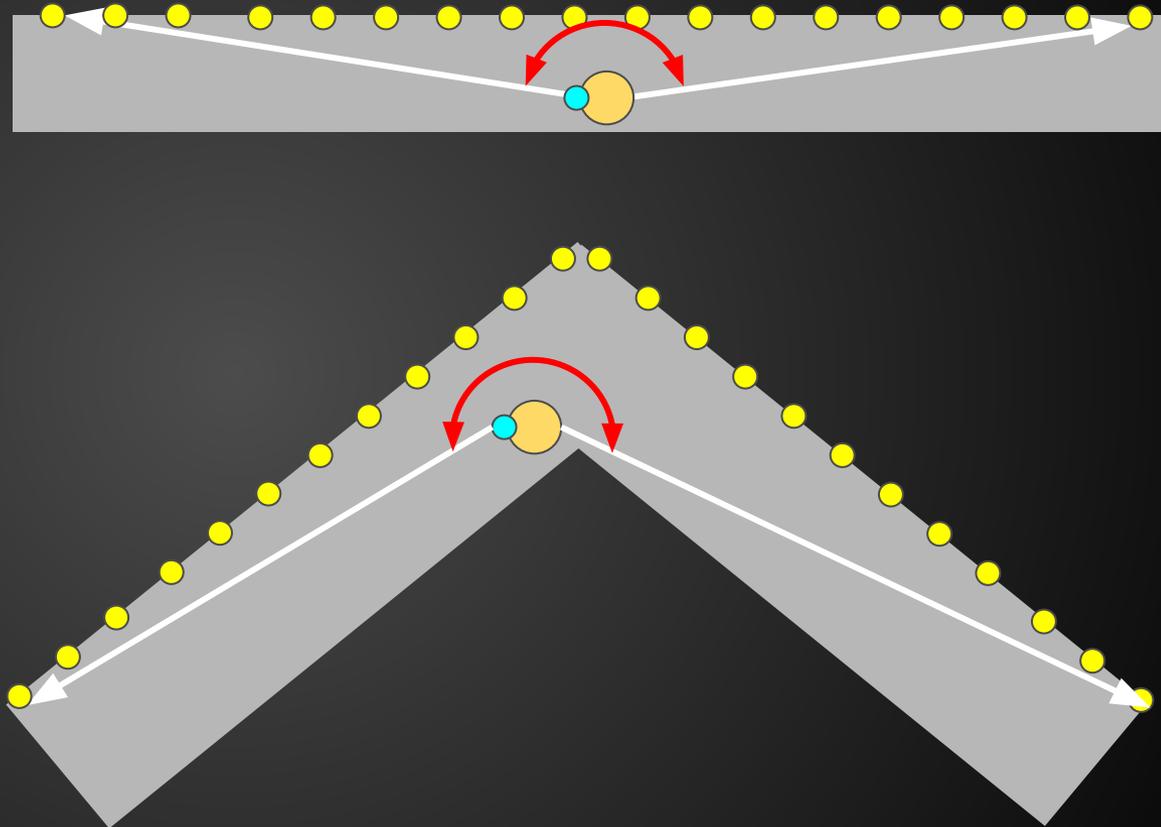
A corrugated surface is advantageous because it increases the efficiency by increasing the view factor of the Hyd for the X nuclei.

## Pd nano-sized multilayer film



# Iwamura's: View Factor Increase With Corrugated Surface

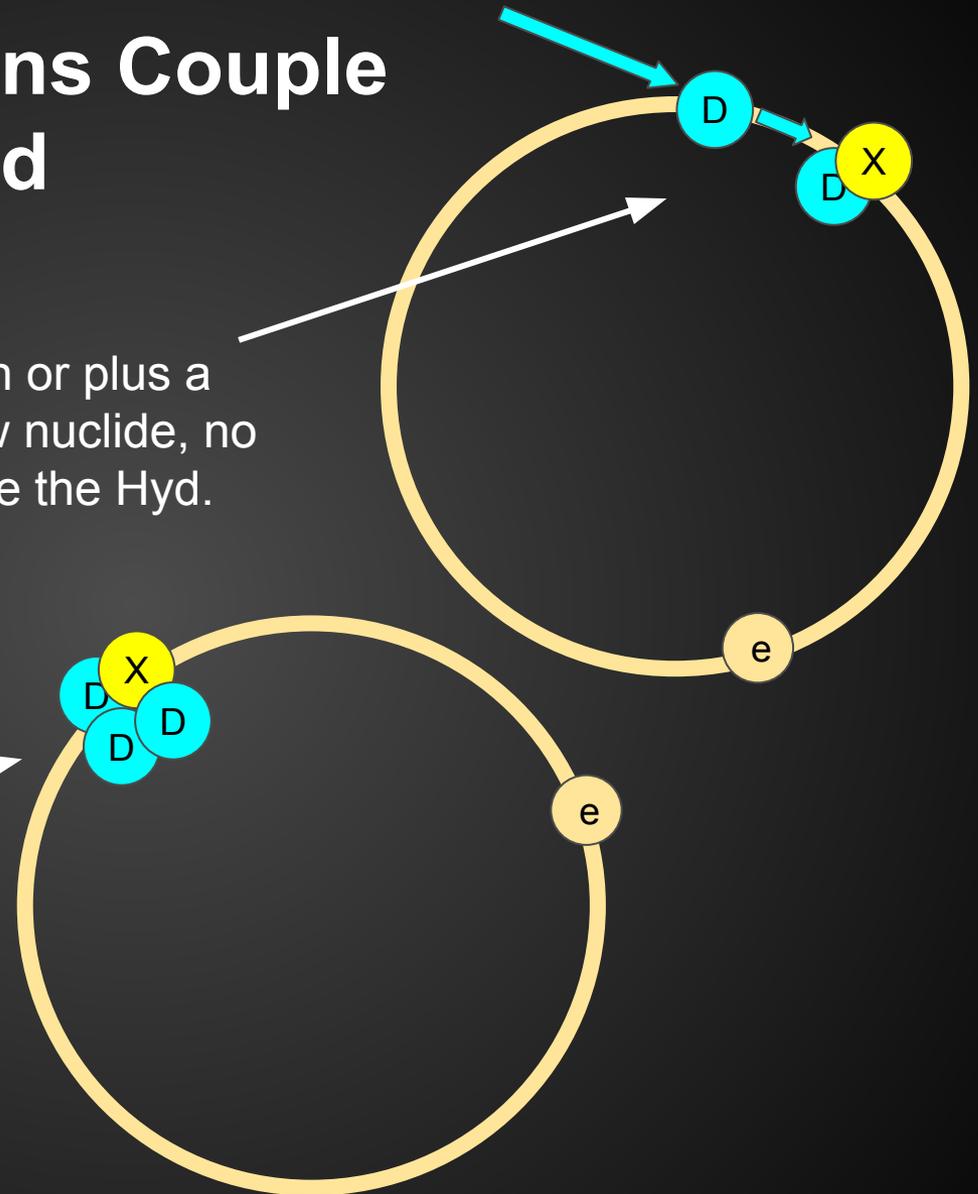
With a corrugated surface the solid angle covered by the deposited atoms seen by the newly formed Hyd is larger than in the flat surface case.



# Iwamura's: Additional Deuterons Couple to the Captured Hyd

If the nucleus of X plus a deuteron or plus a neutron can not form a stable new nuclide, no nuclear reaction takes place inside the Hyd.

Incoming D (adsorbed from the gas phase) can be progressively captured by the "X-Hyd".





# Concerns about the Neutral Radiation

The fact that Cold Fusion generates a neutral and relatively penetrating radiation that can cause nuclear reactions will play an important role in the acceptance and spread of the technology.

So far this aspect has remained a detail, probably due to a series of reasons:

- the radiation tends to remain trapped inside condensed matter,
- only a few experimenters measured the radiation,
- the effects of the radiation are much milder than those of neutrons and hit materials are not “activated”. Only X rays are emitted.

**Before any industrial adoption of the technology it will be necessary to learn how to measure the neutral radiation and its effects on living tissues.**

# Summary of Relevant Features of EMNR

- The nuclear binding energy is electromagnetic.
- The Coulomb barrier is not overcome kinetically.
- Thanks to the mediation of the electron, what we call “nuclear force” can manifest at unusually large distances between oppositely charged particles, leading to the formation of a “neutral nucleus”.
- EMNR release energy as EUV photons during the formation of the Hyd. These photons thermalize in very thin layers.
- The EMNR take place in two stages:
  - First Stage: Formation of the Hydronions,
  - Second Stage: the “neutral” Hyd capture other nuclei which then react “inside the electron”.

# CF Evidences the EMNR Theory can Explain

- The NAE is non-chemical, since the ECO has no role in chemistry.
- EMNR do not produce neutrons in most cases.
- The neutral particles that can reach heavy nuclei are the Hydronions.
- Hyd generate nuclear reactions which prefer stable nuclei.
- Tritium can be produced without neutrons (no branching ratio problem).
- The binding energy of Hyd is emitted as EUV radiation, which thermalises in very thin layers. This explains the very low levels of energetic radiation. It also explains both what Randell Mills measures in his plasmas, and the non-thermal radiation measured by Mitchell Swartz.
- The NAE is not located inside the metal lattice, as Edmund Storms and others keep suggesting.
- The most promising ECOs are those offered by Zr and Li. Probably Iwamura managed to use that of Ca, which however is probably limited in its density.
- The measured radio frequencies emissions are the “NMR” resonances of the Hyd trapped inside metal lattices.
- Biological transmutations become “not-impossible” thanks to a series of the ECO that can be present in organic matter.
- Fracto-fusion can be qualitatively explained.

# What This Theory is NOT

- There is no kinetic overcoming of the Coulomb barrier. Instead there is a force, which is the nuclear force itself, that makes the trick.
- There is no resonance of deuterons inside the Pd matrix.
- No tunneling is proposed.
- No common electron screening: The electron screens the charge of the proton only thanks to the existence of the Hydronions.
- There are not hydrogen clusters, while there could be Hyd clusters.
- There is no need for a Bose-Einstein Condensate at high temperatures.
- No perfect nano-cracks are needed.
- The reactions do not rely on free neutrons.
- There is no need for Superabundant Vacancy formation.
- There is no suggestion of energy concentration beyond common thermodynamic limits.
- There is no significant coupling between the nuclear potential and the phonon bath.
- There are no endothermic reactions that become temporarily exothermic.
- There is no need for a modification of the range of the Weak Interaction.
- Undiscovered metastable nuclear isomers are not required.
- Magnetic monopoles or tachyonic particles are not required.

# Are These “Anomalies” Due to the Hydronions?

- **Possible neutron non-beta decay:**

The mean lifetime of neutrons has been measured in two different ways (bottle and flux experiments) which give two incompatible results. The reason could be a branching decay path different from the beta decay.

[Scientific American recently reported about this.](#)

The neutron decay could have this small branch:

$n \rightarrow p + W \rightarrow ep + \text{antineutrino}$

- **Formation of an unknown particle from proton bombardment of Li7:**

[A recent publication on Physical Review Letters](#) shows an anomaly in the decay of Be8 from the bombardment of Li7 by protons at an energy of 1.15[MeV], near to the third coupling energy of Condition II (see slide [Slide 9](#)). This possibility is better commented in the [next slide](#).

- **Lack of Li7 in the Universe:**

[A recent article on Physical Review Letters](#), suggests the existence of a light (1.6÷20[MeV]), fairly stable neutral particle, which interacts strongly with protons and neutrons.

- **Dark Matter:**

Could it be that primordial plus star-generated Hyds is what constitutes (Light) Dark Matter?

# Formation of an Unknown Particle From Proton Bombardment of Li7

In this reference: [Phys. Rev. Lett. 116, 042501 – Published 26 January 2016](#) it is suggested that a new particle with mass of about **16.7[MeV]** could be responsible for an anomaly in the Internal Pair Creation in Be8:

The EMNR theory suggests that the proton can couple with an electron and form a Hyd at a series of energies:

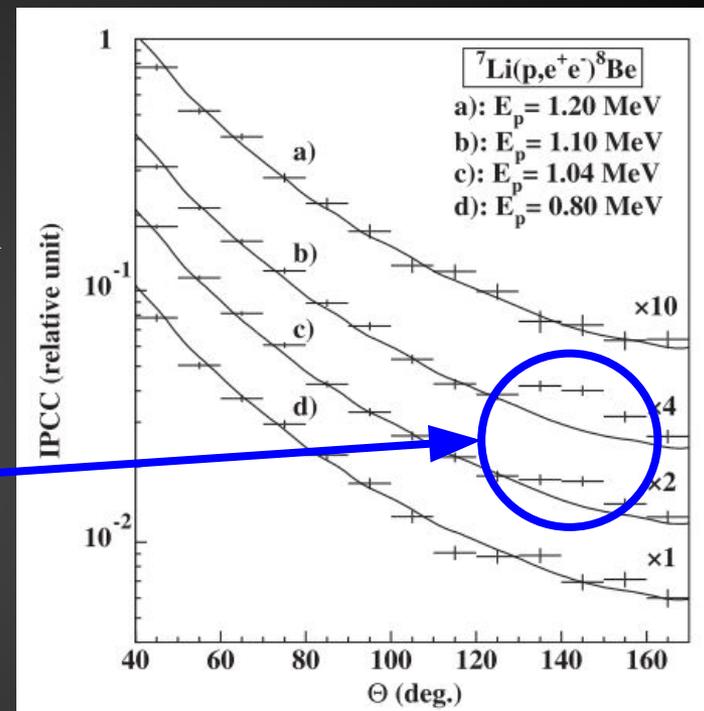
Coupling Integer	Condition I Energy [eV]	Condition II Energy [keV]
1835	642.0	<b>1,178</b>
<b>1836</b>	<b>85.0</b>	<b>156</b>
1837	471.4	866

The third of these energies is near to the energy at which the anomaly appears.

The reason for the estimated particle energy could be the released kinetic energy in the reaction (already shown on [Slide 22](#)):



Is it the sign of an intermediate Hyd?



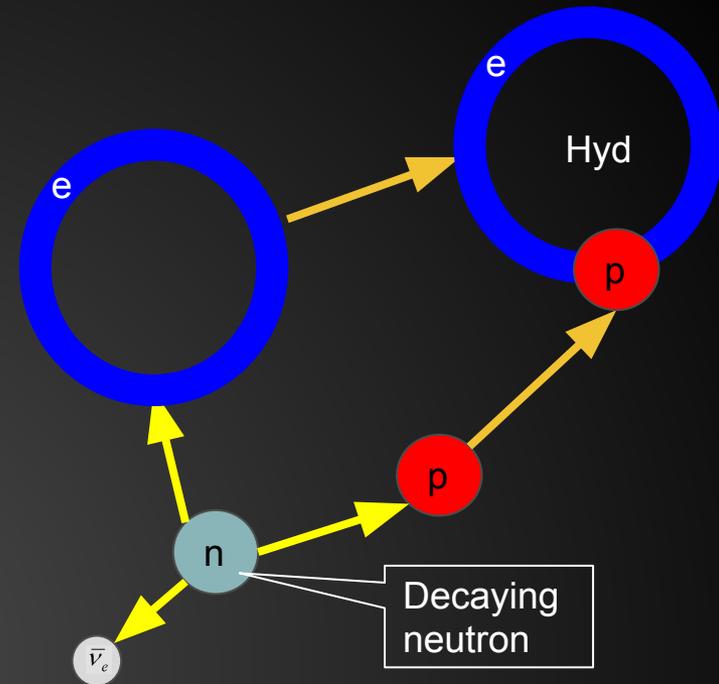
The full curves show the IPC background ( $M1 + 23\%E1$ ). We carried out the experiment at  $E_p = 1.15 \text{ MeV}$  as well (not shown in Fig. 3), slightly above the resonance and obtained about 60% anomaly of the one observed below the resonance at  $E_p = 1.04 \text{ MeV}$ .

# Neutron Decay Branching

The decay of the neutron could have a branching that does not produce  $p + e + h\nu + \bar{\nu}_e$ :



The suggestion is that in a fraction of the decays the electron emitted by the  $W$  is captured by the proton forming a Hyd.



Neutron decay followed by a Hyd formation

Recent accurate measurement of the photon spectrum from the neutron decay confirm theoretical predictions, but can not exclude small branching fractions.

The discrepancy between the neutron half-life estimated by bottle and beam techniques support a small non-beta branching fraction.

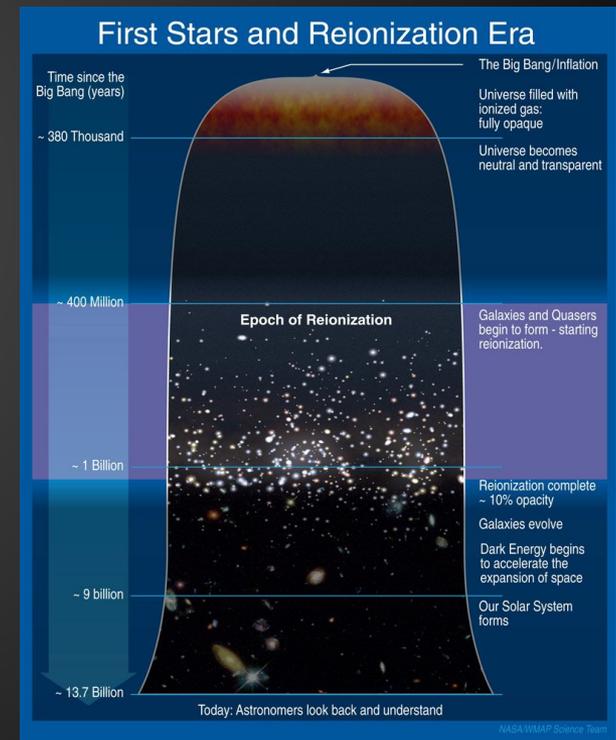
# Dark Matter

Some articles suggest the existence of a Uniform Ultraviolet Background:

- 2014: [The Mystery of the Cosmic Diffuse Ultraviolet Background Radiation](#)
- 2016: [Possible New Horizons Fundamental Contribution to Cosmology](#)

Hyd would form at 85[eV] which is higher than the 13.6 [eV] for the hydrogen atom, so that at hydrogen recombination baryons would fall into already existing potential wells generated by the mass of the Hyds.

What caused reionization? It must have been a source of light at an energy in excess of 13.6 [eV]. Were the 85 [eV] emissions from the Hyds a significant contributor to the ionizing radiation?



# Suggested Experiments

- Accelerate protons or deuterons at a few [eV] against targets made of good NAE atoms in suitable chemical coordinations states like:
  - Re:  $\text{ReO}_3$  (expensive, decomposes at 400 [C], is electron and proton conductive),
  - Br: Bromates (like  $\text{NaBrO}_3$  or  $\text{KBrO}_3$ ),
  - S: Thiosulfates (like  $\text{Na}_2\text{S}_2\text{O}_3$  (low melting point) or  $\text{H}_8\text{N}_2\text{O}_3\text{S}_2$ ),
  - Bi:  $\text{BiF}_5$ ,
  - Ir:  $\text{Ba}_2\text{CaIrO}_6$  (perovskite structure)
  - Zr:  $\text{ZrO}_2$ ,
  - Mg:  $\text{MgO}$ ,
  - Rh:  $\text{RhF}_5$  or  $\text{Sr}_3\text{LiRhO}_6$
  - Cu:  $\text{K}_3\text{CuF}_6$  or  $\text{Cs}_2\text{CuF}_6$
  - Co:  $\text{CoS}_2$ ,
  - Ge:  $\text{GeO}_2$ ,  $\text{GeS}_2$ ,
  - Cr:  $\text{K}_3[\text{Cr}(\text{O}_2)_4]$ ,
  - N:  $\text{NaNO}_2$ ,
  - ...
- Measure EUV emissions.