

# Reazioni nucleari mediate dall'elettrone: forse la forza nucleare non è forte

## Electron Mediated Nuclear Reactions (EMNR)

Andrea Calaon  
Independent Researcher



# Features of the LENR Mechanism to Be Explained

- LERN:
  - produce energy in “Nuclear Amounts” without the huge quanta characteristic of nuclear energy energy differences,
  - do not produce dangerous neutrons and energetic particles,
  - need hydrogen nuclei,
  - have a strong preference for stable nuclei.
- The Coulomb barrier is somehow overcome. Nuclei do it all the time. However it happens only when nucleons reach a distance of about 2 [fm].
- LENR affect not only light, but also heavy nuclei -> There must be something neutral out there.



# Constraints for Any LENR Theory

- 26 Years without an Explanation -> **There must be unexpected physical effect** that affects nuclei, 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 typical “chemical” parameters, i.e. by valence electron orbitals.
- The energy comes from the “force” that 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 is somehow **purely nuclear**.
- The mechanism must prefer stable nuclei.
- The unexpected physical effect should explain ALL occurrences of LENR (Storms ...).



# My Uncommon Assumption

Any LENR theory must propose a single unexpected physical effect. My choice:

- Nuclei are kept together by the electromagnetic interaction through the **Magnetic Attraction Mechanism** 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).

The electron **Zitterbewegung** (ZB) which is a very rapid charge rotation, is not different from the internal charge rotation of the nucleons. **So electrons can be attracted to nucleons by the magnetic force that keeps nucleons together.**



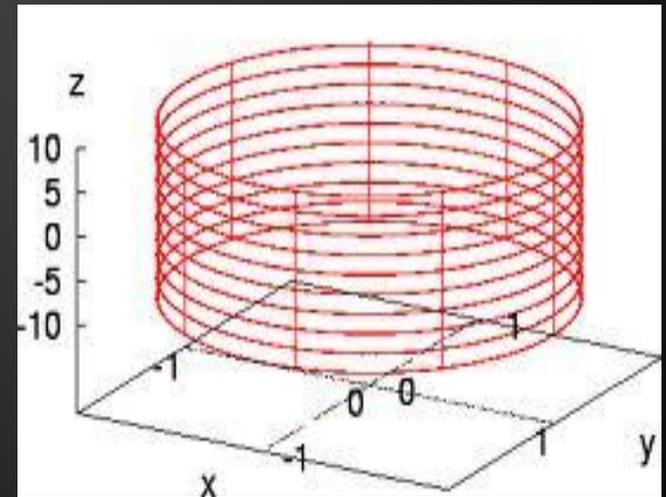
# Magnetic Attraction Mechanism and Zitterbewegung

**Attraction mechanism** (responsible for the nuclear force and for LENR):

- If a particle has a magnetic moment it must generate a magnetic field that varies at the frequency of the charge rotation.  $B = (\mu_0/4\pi)qv \wedge R/|R|^2$
- When another massive particle that has a magnetic moment is immersed into the previous field, the magnetic part of the Lorentz force ( $F = q v \wedge B$ ) generates a “strong” (oscillating) attractive force that can overcome the electrostatic repulsion.

Electron **Zitterbewegung**:

- The electron is a point charge that travels at the speed of light on a “variable pitch - constant radius” trajectory:
  - Radius = 193 [fm].
  - Circular frequency (fixed):  $2.47 \cdot 10^{20}$  [Hz]



# Necessary Conditions for Magnetic Attraction

The necessary conditions for the magnetic attraction are:

- **Alignment** of the Magnetic Moment (i.e. spin): parallel or anti-parallel.
  - **Rotation Speed**: Synchronous rotation or the lower frequency equal to the other divided by an integer.
  - **Phase**: zero for parallel spins and half-cycle for anti-parallel spins.
- 

## For nucleons (Nuclear Force):

- Both nucleons have the same internal charge rotation frequency,
- The necessary phasing can be reached only at short distances. This should be the reason for the short range of the nuclear force.



# Charge Rotation Inside Nucleons

- Inside nucleons the point charges “rotating” are three and have opposite fractional charges. Their average radius is not known.
- The simplest assumption is to consider a single charge rotating at the speed of light and at a fixed radius, similar to the electron case:
  - Rotation radius:  $r = 2 m_{\text{mag}} / (gqc)$
  - Rotation Frequency:  $\omega = r / (2\pi c)$
- In the case of the proton:
  - $r_p = 0.105 \text{ [fm]}$  (much smaller than the charge radius: 0.8775 [fm])
  - $\omega_p = 4.54 \cdot 10^{23} \text{ [Hz]}$
- At typical nucleon separation distances ( $\sim 2 \text{ [fm]}$ ) 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].
- No relativistic corrections are used.



# Coupling Between an Electron and a Hydrogen Nucleus

- One necessary condition for the attraction is about the frequency relationship.
- Electron and nucleon frequency are quite different:  
 $\nu_p/\nu_e = 1,836.152\dots$  which happens to be  $= m_p/m_e$
- It is impossible to reach a synchronous rotation. But it is possible for the electron to reach  $\nu_p/1836$ . The missing “orbital” frequency is  $2.055 \cdot 10^{16}$  [Hz].

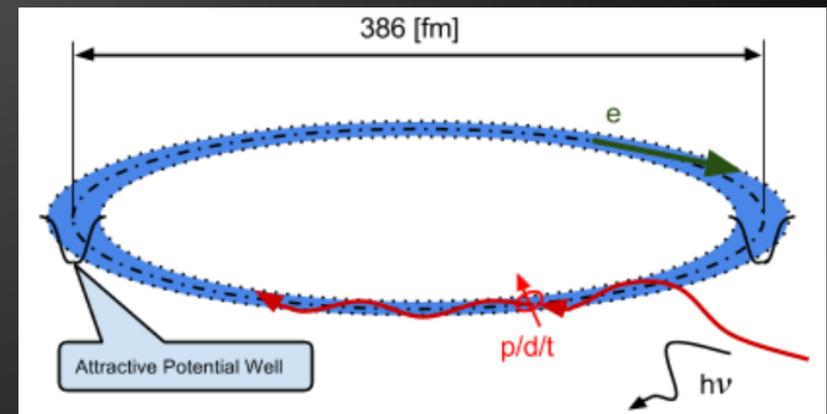
$$\Delta\nu = \left( \frac{\nu_p}{1,836} \right) - \nu_e = \nu_p \left( \frac{\frac{\nu_p}{\nu_e} - 1,836}{1,836 \frac{\nu_p}{\nu_e}} \right) = 2.055 \cdot 10^{16} [Hz]$$

- This frequency corresponds to an energy of  $85$  [eV] and to a wavelength of  $14.6$  [nm], in the Extreme UltraViolet.
- In the NAE electron and nucleons should see each other rotating at this frequency/energy.



# Coupling between Electron and Hydrogen Nucleus

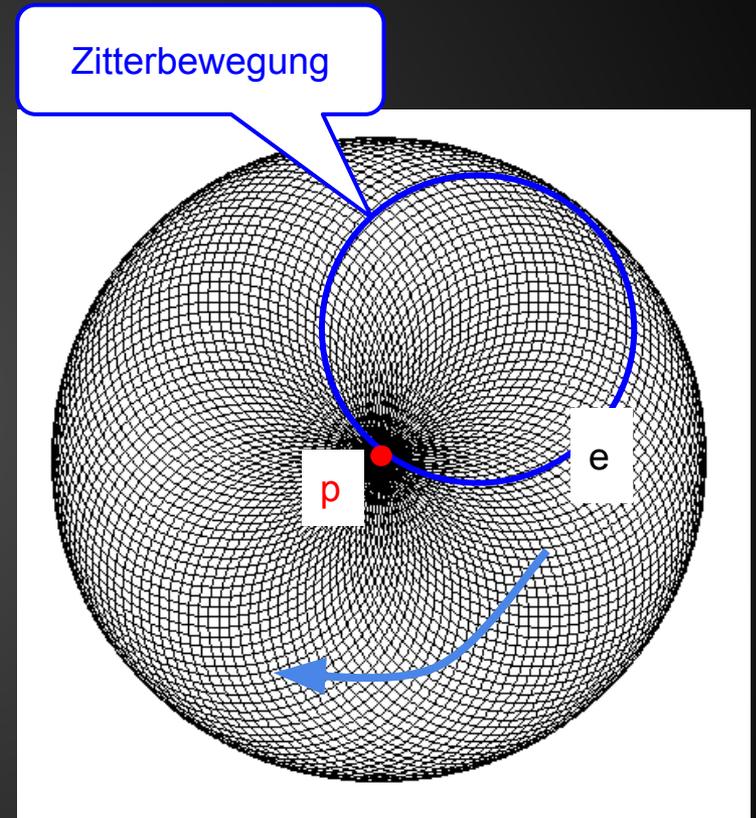
- If all necessary conditions are satisfied the hydrogen nucleus and the electron feel the attractive force and accelerate towards each other radiating photons in the EUV range.
- The electron has a “diameter” of 386 [fm], therefore is much bigger than the nucleons.
- When the hydrogen nucleus passes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



# How Hydronions Could 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 fixed at the hydrogen nucleus location and turning around it at about  $2.055 \cdot 10^{16}$  [Hz].

The picture is clearly not to scale.



# Reactions Generating Hydronions



$G_p$ ,  $G_d$  and  $G_t$  are the binding energies of the Hydronions.

Hydronions are neutral and can attract other nuclei, so that the LENR is 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 at very low excess kinetic energy.

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 (see Mitchell Swartz’s work).



# Properties of the Hydronions

Hydronions travel freely inside matter and can penetrate electron shells:

- maximum charge displacement vector = 386 [fm]
- pulsation frequency around  $10^{20}$  [Hz]
- magnetic moment: 960 times that of the neutron
- size: the area of the Hyd is about 52,000 the section of the neutron.

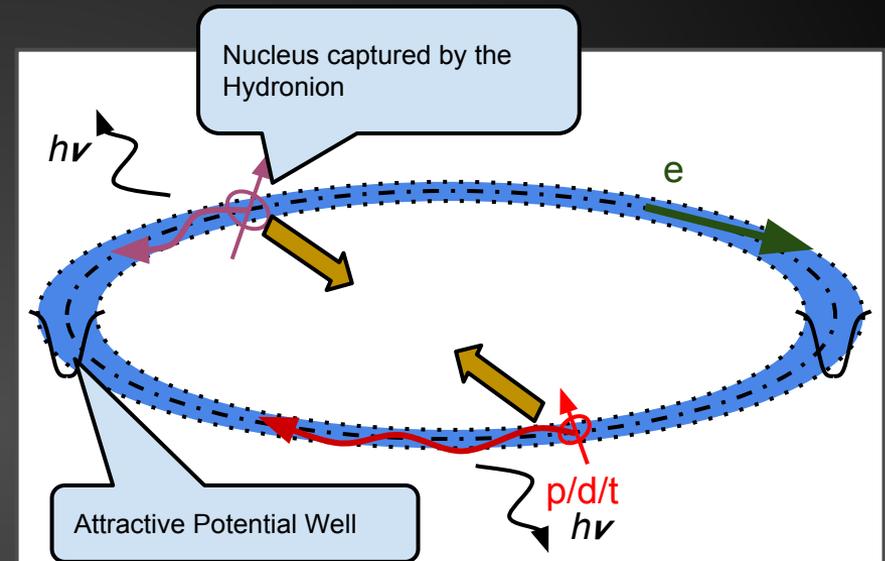
Therefore Hyd should be scatter significantly in condensed matter and some could end up trapped in solid lattices (where the magnetic field gradient is higher).

Magnetic fields should deviate the Hyd trajectory in vacuum or in a plasma.



# Second Stage Reactions

- Hydronions can capture other nuclei and have them react “inside” the ZB trajectory of the electron.
- It is also possible that the electron of the Hyd can host more than two nuclei. The reaction could also be delayed until a stable nucleus can form (I will comment this later).



## Effect of Phonons

- In condensed matter part of the produced Hyd get trapped. Phonons, thanks to the magnetoelastic coupling, should be able to squeeze the Hyd out helping them to further react. This would explain the effect of phonons on the heat release rate.



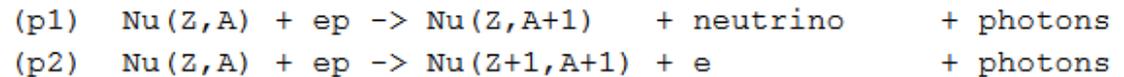
# Types of Second Stage Reactions

The electron can participate to the nuclear reaction if it crosses the nuclei while they are reacting.

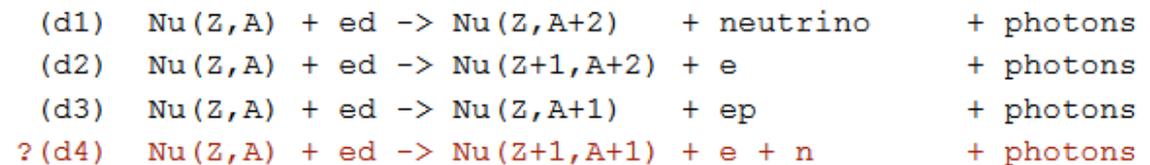
If the trapped nuclei can react without the participation of the electron, the reaction in which the electron participate becomes significantly less probable (less than 2.5%).

The variety of the second stage reactions is responsible for the many unidentified gamma emission lines.

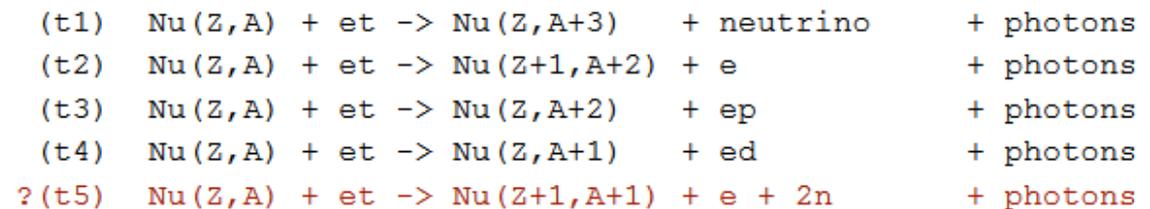
## With **Hydronius (ep)**:



## With **Deuteronius (ed)**:



## With **Tritonius (et)**:



# Second Stage Reactions: Hydrogen Isotopes Only

When Hyd meet only hydrogen nuclei the possible reaction 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.

If  $G_p > 1.442$  [MeV] reaction 1e is endothermic.

When  $4\text{He}$  is produced there is a large energy release.

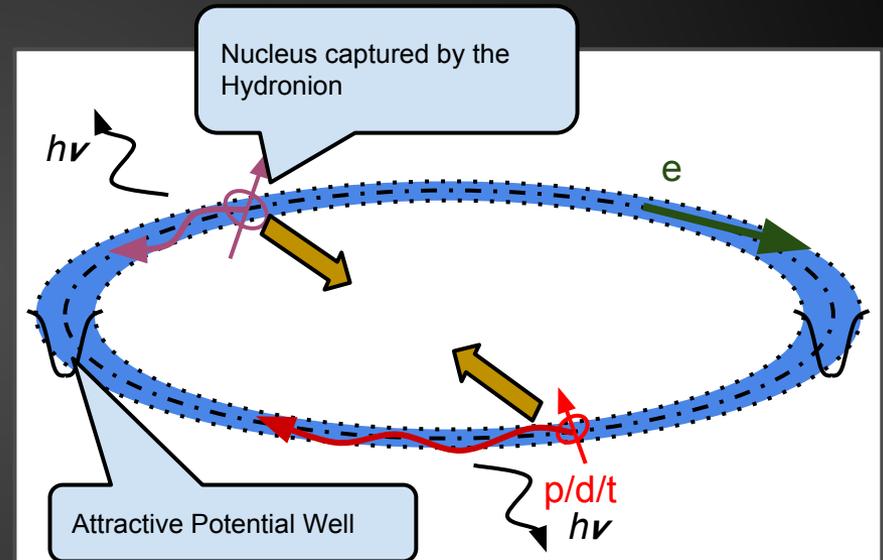
7 : <b>t</b> (beta decay)	-> <b>He3</b> + e + antineut. + (aver)	5.7 [KeV]
8e : <b>He3</b> +ep	-> <b>He4</b> + neutrino + (max)	19.80 [MeV]
9 : <b>He3</b> +ed	-> <b>He4</b> + ep + (max)	20.58 [MeV]

è forte



# 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, therefore it perturbs continuously the forming nuclei and break them apart (a sort of forced decay) if they are not stable enough. So only the most stable nuclear configurations (certain lattices) can survive.
- The electron perturbation is not limited to the short crossing time (a few [fm] at the speed of light), but is continuous, with a maximum when the crossing takes place.

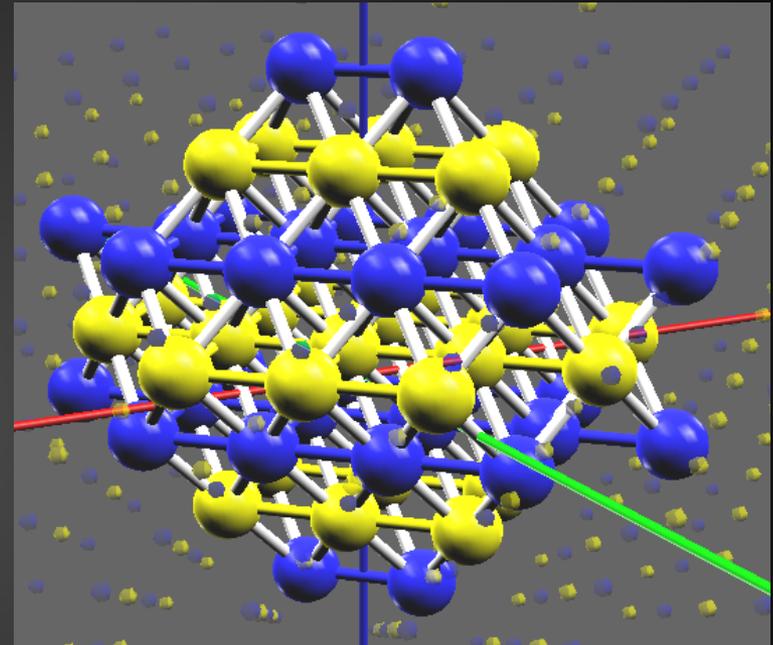


# Non-Reacting Nuclei

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

An example:

Ni62 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.



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>



# No Tritium Accumulation

Magnetic Moments of hydrogen isotopes:

$$m_d/m_p = 0.31 \qquad m_t/m_p = 1.07$$

So the reactions with deuterium should be kinetically slower than those with protium and tritium.

## Sources of tritium:

2e : p+ed	-> <b>t</b> + neutrino + (max)	5.475 [MeV] - Gd
3e : d+ep	-> <b>t</b> + neutrino + (max)	5.475 [MeV] - Gp
4.2: d+ed	-> <b>t</b> + ep +	4.033 [MeV] - Gd + Gp

## Tritium Sink:

5 : <b>t</b> +ep	-> <b>He4</b> + e +	18.792 [MeV] - Gp
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The elimination of tritium should be faster than its production (endothermic reactions are not listed).

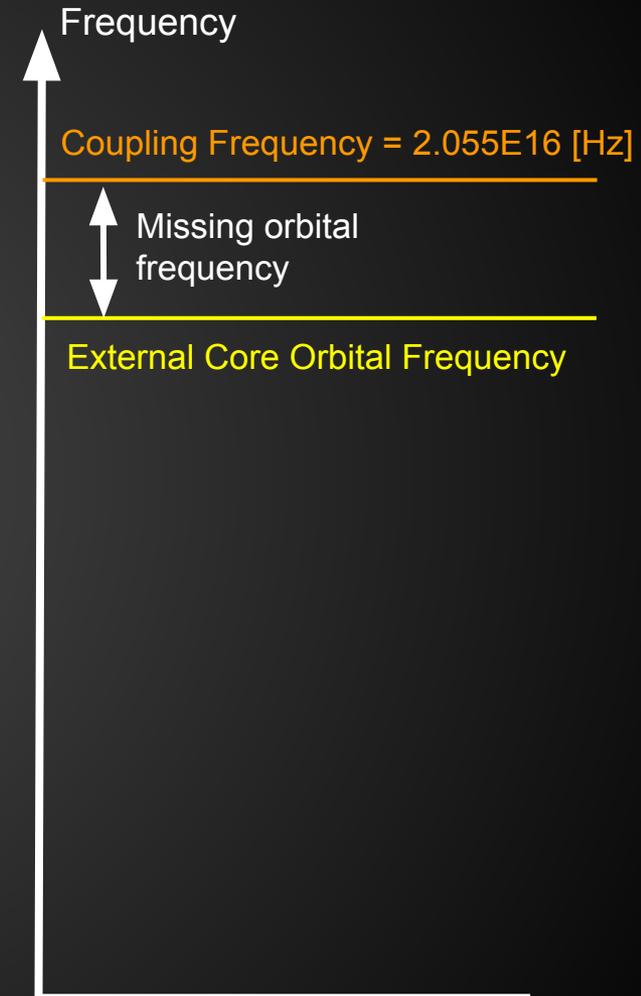
This should be the reason for the lack of accumulation of tritium and for its reported elimination.



# The Nuclear Active Environment (NAE)

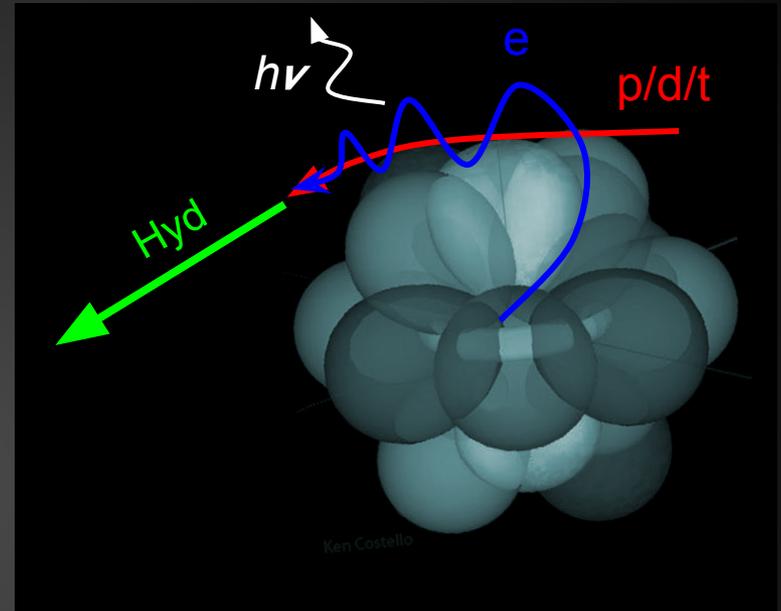
The most important bit of theory, necessary for any real LENR application is the NAE:

- The required frequency to be added to the intrinsic electron charge rotation frequency to reach the intrinsic charge rotation of nucleons divided by 1836, is  $2.055 \cdot 10^{16}$  [Hz].
- The corresponding energy is 85 [eV].
- Core orbitals reach and surpass this energy, while valence orbitals never reach it.
- If a core orbital that has a nearby energy is exposed and is stricken by a hydrogen nucleus with the correct speed the coupling can take place.



# The Nuclear Active Environment

Once the electron in the orbital and the striking proton see each other rotating at the coupling frequency, they attract each other.



The coupling happens only at a specific frequency, so as the electron approaches the hydrogen nucleus it should spiral at a constant frequency. In this phase the distance decreases so the electron should emit energy in the form of EUV near to the wavelength of 14.6 [nm].



# The Nuclear Active Environment

- The NAE is the combination of:
  - A naked ECO, that has an energy near to the coupling energy,
  - A naked hydrogen nucleus that strikes the ECO with at the right speed.
- The naked ECO can be found in solids, liquids or plasmas.
- The NAE depends on something that has no role in chemistry: the External Core Orbital. Therefore Many 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 striking the naked ECO with the right energy,
  - even when that happens the density of the accelerated hydrogens is so low that there is no appreciable macroscopic effect.
- The NAE is not located inside metal hydrides.
- In electrochemical experiments the NAE is in the oxide layers.
- The energy to be given to the hydrogen nuclei depends on the energy of the naked ECO; when that is near to the coupling energy the energetic barrier can be made very low (Iwamura).



# Which are the Best NAE?

Ionization energies of atoms. In ionic bonds these energies are not too far from the real ECO energies.

The best ECO for the coupling are:

- Ca(IV) at only less than an [eV]. Is Iwamura using this? Ca(IV) should not be present ...
- The best stable option appears to be Zr(IV). Mitchel Swartz uses it.
- A second good option should be Mg(II). Iwamura says it does not work, but his hydrogen have very low energies.
- Li(I) is a good option, while it requires a higher hydrogen energy (electrochemical or “plasma”). Rossi, Lipinsky, electrochemisty, ...
- N(III) should be also interesting: blue Palladium?

Element	Ionization state	Ionization Energy [eV]	Complementary Energy [eV]	Ordinary State
Ca	+4	84.50	0.50	no
Rb	+5	84.4	0.60	no
Ga	+4	87.00	-2.00	no
F	+3	87.14	-2.14	no
K	+4	82.66	2.34	no
Zn	+4	82.60	2.40	no
S	+5	88.05	-3.05	"yes"
Bi	+5	88.30	-3.30	"yes"
Se	+5	81.70	3.30	"yes"
Br	+5	88.60	-3.60	"yes"
Zr	+4	80.35	4.65	yes
Mg	+2	80.14	4.86	yes
Co	+4	79.50	5.50	"yes"
Cr	+5	90.63	-5.63	yes
Kr	+5	78.50	6.50	no
Sc	+4	91.65	-6.65	no
N	+3	77.47	7.53	yes
O	+3	77.41	7.59	no
Y	+5	93.00	-8.00	no
Y	+4	77.00	8.00	no
Ge	+4	93.5	-8.50	yes
Ni	+4	76.06	8.94	yes
Li	+1	75.64	9.36	yes
Mn	+5	95.60	-10.60	yes
Sc	+3	73.49	11.51	yes



# Summary of Relevant Features of EMNR

- The Coulomb barrier is not overcome kinetically.
- The nuclear binding energy is electromagnetic.
- 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 can release energy as EUV photons during the formation of the Hyd and during the nuclear approach inside the electron. 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”.



# What the EMNR Theory can Explain

- The NAE is non-chemical, since the ECO does not participate in the chemical binding.
- The LENR do not produce neutrons in most cases.
- Hyd generate nuclear reaction which prefer stable nuclei.
- The neutral entities that can reach heavy nuclei are the Hydronions.
- Tritium is produced without neutrons (no branching ratio problem).
- The strange radiation that is neutral but is deviated by the magnetic field is made of Hyds
- The binding energy of Hyd is emitted in the EUV, which in very thin layers thermalized. This explains the absence of energetic radiation. It also reconciliates what Randell Mills measures in his plasmas and the non-thermal radiation of Mitchell Swartz.
- This theory suggests an interpretation for two most energetic gamma energies measured by Iwamura.
- The NAE is not inside a metal matrix, as Edmund Storms and others keep suggesting.
- The most promising ECOs are those of Zr(IV) and Li(I). Probably Iwamura managed to use that of Ca(IV), which however is not present in common chemical compounds.
- The measured **radio frequencies** emissions are the “NMR” frequencies of the Hyd trapped inside metal matrices. With only a 2 [G] magnetic field the resonance frequency is 5.6 [MHz].
- 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.
- The strange radiation emerging from exploding wires has the features of the Hydronions.



# What This Theory is NOT

- There is no kinetic overcoming of the Coulomb barrier. 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 structure of the Hydronions.
- There are not hydrogen 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 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 short range of the Weak Interaction.
- Does not require undiscovered metastable nuclear isomers.
- Does not require tachyonic particles.

