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Research Article

Yet Another LENR Theory: Electron-mediated Nuclear Reactions (EMNR)

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Abstract

An attempt is made to build an LENR theory that does not contradict any basic principle of physics and gives a relatively simple explanation to the plethora of experimental results. A single unconventional assumption is made, namely that nuclei are kept together by a magnetic attraction mechanism, as proposed in the 1980s of the past century by Valerio Dallacasa and Norman Cook. This assumption contradicts a non-proven detail of the standard model, which instead attributes the nuclear force to a residual effect of the strong interaction. The theory is based also on a property of the electron which has been known for long, but has rarely been used: the Zitterbewegung (ZB). This property should allow the magnetic attraction mechanism that binds nucleons together, to manifest also between the electron and any isotope of hydrogen, leading to the formation of three neutral pseudo-particles (the component particles remain separate entities), collectively named here Hydronions (or Hyd). These pseudo-particles can then couple with other nuclei and lead to a fusion reaction "inside" the electron. The Coulomb barrier is not overcome kinetically, but through what could be interpreted as a range extension of the nuclear force itself, realized by the electron when some specific conditions are satisfied. The most important of these necessary conditions is that the electron has to "orbit" the hydrogen nucleus at a frequency of 2.055×10^{16}Hz. This frequency corresponds to photons with an energy of about 85 eV or equivalently a wavelength of 14.6 nm in the Extreme Ultra Violet (EUV). So the large quanta of nuclear energy fractionate into EUV photons during the formation of the Hydronions and during the coupling of Hydronions to other nuclei. The formation of Hydronions requires the so called Nuclear Active Environment (NAE), which is what makes LENR so rare and difficult to reproduce. The numbers suggest that the NAE forms when an unshielded atomic core electron orbital that has an "orbital frequency" near to the coupling frequency is stricken by a naked Hydrogen Nucleus (HNu). This theory therefore implies that the NAE is not inside the metal matrix, but in its immediate neighbourhood. The best candidate atoms for a NAE are listed, based on the energy of their ionization energies. The coincidence with the most common LENR materials appears noteworthy. The Electron Mediated Nuclear Reactions (EMNR) theory can explain also very rapid runaway conditions, radio emissions, biological NAE, and the so called "strange radiation".
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Keywords: EMNR theory, Extreme ultra violet, Hydronion, Magnetic attraction, Strange radiation, Zitterbewegung

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1. Background

The fact that LENR phenomena have been discussed for 26 years and no widely accepted explanation has emerged, suggests strongly that the phenomenon is based on some new or not commonly accepted fact of physics. Any theory trying to explain LENR must therefore have such an “unconventional ingredient”.

2. Uncommon Assumption and Electron Nuclear Interaction

The theory proposed here is based on a single “uncommon” assumption, namely that nuclei are kept together by the electromagnetic interaction through the magnetic attraction mechanism proposed by Dallacasa and Cook, e.g. [1,2]. The approach assumes that the magnetic moment of nucleons comes from the rotation of charges (quarks), and not from gluons or intrinsic properties of the quarks. This contradicts a part of the standard model that is so far unproven (e.g. [3]).

The attraction mechanism depends only on the rotation of a point charge. Therefore the electron, with its Zitterbewegung (not different from the supposed internal charge rotation of the nucleons), should be subject to the same magnetic attraction. In other words the electron, if a series of conditions are satisfied, could be affected by what everyone calls the nuclear force. It will be shown that the necessary conditions are not commonly present in condensed matter.

3. Magnetic Attraction Mechanism

The description of the attraction mechanism done by Dallacasa and Cook in [1] is repeated here with some minor changes to the original proposal. If a particle has a magnetic moment it must generate an oscillating magnetic field. Here it is assumed that the magnetic moment of all particles is due to the rotation of a single charge travelling along a circular orbit at the speed of light (c). Whereas this assumption is essentially in accordance with what we know about the electron [4], it is not so for the nucleons, which have three fractional charges of opposite sign. However, for this simple case, one gets:

- Rotation radius: $r = 2\frac{m_{\text{mag}}}{gqc}$.
- Circular frequency: $\nu = \frac{c}{2\pi r}$,

where m_{mag} is the magnetic moment, g the gyromagnetic ratio and q the particle charge.

Let us now evaluate the oscillating magnetic field. Since non-accelerated particles do not emit electromagnetic radiation, the associated magnetic field can not have a radiative component, and can only correspond to the so-called “static” part of the Liénard–Wiechert potential. Moreover, since the speed of the charge is assumed to be equal to c, the only expression for B that could make sense is the simple Biot–Savart law:

$$B_1 = \frac{\mu_0}{4\pi}\frac{q_1\nu_1 \wedge |R_{12}|}{R_{12}^2}, \tag{1}$$

where the subscript 1 is for the emitting charge, and 2 for the place where the magnetic field is evaluated. μ_0 is the vacuum permeability, v_1 the particle speed (in modulus equal to c), R_{12} the radius vector at which the magnetic field has to be evaluated, and $|R_{12}|$ the unit vector in the direction of the vector R_{12}.

When another massive particle with a magnetic moment is immersed into this magnetic field, the magnetic part of the Lorentz force ($F_2 = qv_2 \wedge B_1$) generates a “strong” (oscillating) attractive force. The formula is

$$F_2 = \frac{\mu_0}{\pi}\frac{m_{\text{mag}_2}}{g_2 r_2}\frac{m_{\text{mag}_1}}{g_1 r_1}\frac{|\nu_1| \wedge |\nu_2| \wedge |R_{12}|}{R_{12}^2}, \tag{2}$$

where the m_{mag} are the magnetic moments of the two particles, v the charge speeds, r the charge rotation radius and the notation $|.|$ means a unit vector.

The attractive force reaches high values only if some necessary conditions are satisfied:

- *Alignment*: of the two magnetic moments (i.e. spin): parallel or anti-parallel, apart from precession.
- *Frequency*: the two particles must have the same frequency (synchronous rotation) or one frequency must be an exact integer multiple of the other.
- *Phase*: zero for parallel spins or half-cycle for anti-parallel spins.

In the case of the proton:

- $r_{\text{p}} = 0.105$ fm (much smaller than its charge radius, which is around 0.87 fm),
- $\nu_{\text{p}} = 4.54 \times 10^{23}$ 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. So, if both nucleons have the same internal charge rotation frequency this kind of force could well be responsible for the so-called "nuclear force". This is what Cook and Dallacasa suggest. Many more considerations could be added regarding this attraction mechanism.

4. Electron Zitterbewegung

The electron manifests as a point charge with an intrinsic and very rapid circular rotation at 2.47×10^{20} Hz, the so-called Zitterbewegung [4]. The rotational motion takes place around the "trajectory" of the electron's centre of mass. The apparent radius of the ZB, as seen by an external (inertial) observer shrinks as the electron speed approaches c (the mass is inversely proportional to the ZB radius). The "static" radius is about 193 fm, much larger than the nucleons, but only about 0.36% of the Bohr radius. The only value that makes sense for the module of the charge speed along the ZB trajectory is the speed of light. The spin, the magnetic dipole moment and the nature of the electron orbitals can be interpreted as consequences of this very rapid charge rotation.

5. Coupling Between Electron and Hydrogen Nucleus

One of the necessary conditions for a net attraction between an electron and a hydrogen nucleus is about the ratio of their intrinsic charge rotation frequencies. This ratio is $\nu_{\text{p}}/\nu_{\text{e}} = 1836.15267389$, and corresponds exactly to the mass ratio of the two particles ($m_{\text{proton}}/m_{\text{electron}}$), or to the inverse ratio of their charge radii ($r_{\text{e}}/r_{\text{p}}$). This ratio is not an integer number and gives no net magnetic attraction.

For the coupling an orbital component of the electron frequency has to be provided. Reaching a synchronous intrinsic charge rotation would require to add to the electron an orbital frequency corresponding to an energy near to 2 GeV, which is far more than any nuclear binding energy, not to mention chemical energies. So the only way to have an attraction between the electron and a hydrogen nucleus is for the electron to "rotate around the nucleus" at a frequency that, added to its intrinsic frequency, reaches 1/1836 of the proton intrinsic frequency (1836 is the nearest integer to the mass ratio). So the necessary orbital contribution $\Delta\nu$ to the electron intrinsic frequency is

$$\Delta\nu = \left(\frac{\nu_{\text{p}}}{1836}\right) - \nu_{\text{e}} = \nu_{\text{p}}\left(\frac{\frac{\nu_{\text{p}}}{\nu_{\text{e}}} - 1836}{1836\frac{\nu_{\text{p}}}{\nu_{\text{e}}}}\right) = 2.055 \times 10^{16}\ \text{Hz}. \tag{3}$$

This frequency corresponds to a photon energy of about 85 eV, or equivalently to a wavelength of 14.6 nm, in the EUV range.

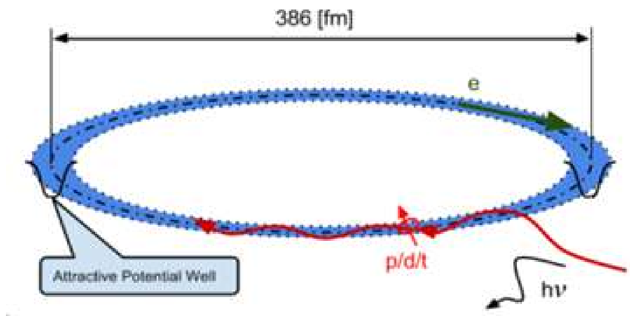

Figure 1. Schemc view of a hydronion with the HNu bound to move along the ZB trajectory.

5.1. Electron orbitals as NAE

Electron orbitals can provide a significant part of the necessary orbital frequency. The rest could come from the energy of the HNu striking the orbital. Valence orbitals have energies always lower than 85 eV and only core orbitals can reach it. Such core orbitals share always their space with other inter-penetrated orbitals, which should prevent the coupling. So in common conditions the electron does not feel any (nuclear) net force towards nuclei.

5.2. Formation of the hydronions: extreme ultraviolet emissions

When an electron and a proton start being attracted towards each other through the magnetic mechanism described above the electron will spiral around and towards the proton. The coupling mechanism is attractive only when the mentioned orbital frequency contribution is present, therefore the electron will spiral towards the HNu at a frequency near to the coupling frequency. This causes the photon emissions to be all in the EUV wavelength range. When the hydrogen nucleus crosses the ZB radius (actually it is the electron that moves towards the HNu, because of the mass ratio) the attractive magnetic force becomes repulsive, and the hydrogen nucleus is captured along the ZB trajectory, as schematically shown in Fig. 1. So the approach produces a bound state between the electron and the HNu. The result is not a new particle because electron and HNu remain separate entities, but it is *a sort of huge and flat neutral nucleus*.

Due to the mass ratio the electron trajectory would look more like a circle fixed at the hydrogen nucleus location, turning around it at about 2.055×10^{16} Hz.

Randell Mills measures in his plasmas [5] an unusual and intense EUV radiation with a wavelength roughly between 10 and 30 nm (the distribution looks roughly like a Cauchy with $E_0 = 65$ eV and $\Gamma/2 = 13$ eV), right across the coupling energy. In light of the present theory Mills should be measuring the emissions due to the formation of Hydronions. EUV radiation is not too easy to measure, while it is absorbed very efficiently in matter and readily transforms into heat. This should be the reason why it was not directly detected in most experiments.

5.3. Three hydronions

As the stable isotopes of hydrogen are three, there are three possible reactions that generate three different Hydronions:

0p:	p+e	$\rightarrow$	pe (hydronius)	+	G_p (MeV)
0d:	d+e	$\rightarrow$	de (deuteronius)	+	G_d (MeV)
0t:	t+e	$\rightarrow$	te (tritionius)	+	G_t (MeV)

$G_{\mathrm{p},}G_{\mathrm{d},}$ and G_t stand for the binding energies of the Hydronions.

6. EMNR Take Place in Two Stages

Hydronions have a maximum charge displacement vector of 386 fm and a pulsation frequency around 10^{20} Hz (half of the "reduced" Compton length and frequency), therefore they should travel much more freely than electrons and nuclei inside matter. However, they have a very large magnetic dipole moment if compared to neutrons in fact their magnetic moment is practically equal to the electron's magnetic moment. So their trajectory in free space should be strongly influenced by the presence of a varying magnetic field.

Hydronions can be attracted by other nuclei towards the ZB trajectory though the magnetic attraction. Once the HNu and the second nucleus are both moving along the ZB (like on a race track), they will attract each other through the magnetic attraction because now their magnetic moments are aligned and probably will phase. Figure 2 tries to depict this. As it is well known, the nuclear reaction between the two nuclei takes place only when their distance is down to a few femtometres. In the Quantum Nucleodynamics theory of Cook [1], a nuclear reaction corresponds simply to a rearrangement of the fcc nucleon structure.

The electron provides very special conditions for a nuclear reaction, which is the reason why LENR do no generate the same products of hot fusion; in particular they avoid unstable nuclides. This is one of the most astounding features of LENR the one that make them so interesting, both for energy production and for nuclear waste deactivation. The qualitative physical reason for the preference for stable nuclides should be the fact that the electron of the Hyd keeps perturbing the reacting nuclei, so that the most unstable nuclei can not assemble completely. When the new nuclei being assembled inside the Hyd survive the perturbing action of the electron, the system releases the excess energy and emits photons. The Hyd probably breaks apart after any nuclear reaction that has an energy release higher than its binding energy.

The nuclear reaction that takes place along the electron's ZB can be both a fusion of the HNu (possibly together with the electron) or a fission. Depending on the hydrogen isotope of the Hyd, there are a series of possibilities for the

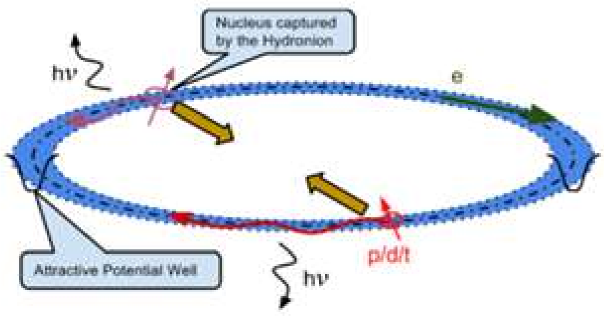

Figure 2. A Hyd has "captured" a nucleus and the two nuclei attract each other emitting photons.

possible *fusion* reactions:

With hydronius (ep)

(p1)	Nu(Z, A)	+	ep	$\rightarrow$	Nu$(Z, A+1)$	+	neutrino	+	photons
(p2)	Nu(Z, A)	+	ep	$\rightarrow$	Nu$(Z+1, A+1)$	+	e	+	photons

With deuteronius (ed)

(d1)	Nu(Z, A)	+	ed	$\rightarrow$	Nu$(Z, A+3)$	+	neutrino	+	photons
(d2)	Nu(Z, A)	+	ed	$\rightarrow$	Nu$(Z+1, A+2)$	+	e	+	photons
(d3)	Nu(Z, A)	+	ed	$\rightarrow$	Nu$(Z, A+1)$	+	ep	+	photons
?(d4)	Nu(Z, A)	+	ed	$\rightarrow$	Nu$(Z+1, A+1)$	+	e + n	+	photons

With tritionius (et)

(t1)	Nu(Z, A)	+	et	$\rightarrow$	Nu$(Z, A+3)$	+	neutrino	+	photons
(t2)	Nu(Z, A)	+	et	$\rightarrow$	Nu$(Z+1, A+2)$	+	e	+	photons
(t3)	Nu(Z, A)	+	et	$\rightarrow$	Nu$(Z, A+2)$	+	ep	+	photons
(t4)	Nu(Z, A)	+	et	$\rightarrow$	Nu$(Z, A+1)$	+	ed	+	photons
?(t5)	Nu(Z, A)	+	et	$\rightarrow$	Nu$(Z+1, A+1)$	+	e + 2n	+	photons

The reactions with the question mark probably are impossible. For the possible *fission* reaction the combinations are many more than those of a fusion.

LENR, which the present theory rename EMNR, take place in two stages:

- *First stage*: Generation of Hydronions (this stage needs a NAE).
- *Second stage*: The Hyd are captured by other nuclei and host nuclear reactions inside the electron.

The flow of Hyd is the "strange radiation" detected in many LENR experiments, as thoroughly summarized in [6]. The second stage should be responsible for the meta-chronous thermal effects and the double optimal operating power measured by Mitchell Swartz (see [7]) and other experimenters. The non-thermal Near-IR radiation measured by Swartz and Verner [8] is due to the not completely thermalized EUV emission; the authors of the paper attributed it to Bremsstrahlung. The strong EUV emission could be part of the reason for the sudden change in resistance of the Nanors that has caused so many electrical equipment failures.

7. Second Stage Reactions with Hydrogen Nuclei

When Hyd react with hydrogen nuclei the possible reactions are shown below.

7.1. Remarks

- All reactions involving the weak interaction (where a neutrino is emitted and a proton combines with an electron to give a neutron) are kinetically much slower than those which do not involve the weak interaction

1e	p+ep	$\rightarrow$	d	+	Neutrino+ max)	1.442 (MeV)	-	$G_{\rm p}$
2e	p+ed	$\rightarrow$	t	+	Neutrino+(max)	5.475 (MeV)	-	$G_{\rm d}$
3e	d+ep	$\rightarrow$	t	+	neutrino+ max)	5.475 (MeV)	-	$G_{\rm p}$
3	d+ep	$\rightarrow$	He^3	+	e +	4.472 (MeV)	-	$G_{\rm p}$
4e	d+ed+0.141 (MeV)+$G_{\rm d}$	$\rightarrow$	H^4	+	neutrino +	0.00 (MeV)		
	H^4	$\rightarrow$	t	+	n +	3.391 (MeV)		
4.1	d+ed	$\rightarrow$	He^4	+	e +	22.825 (MeV)	-	$G_{\rm d}$
4.2	d+ed	$\rightarrow$	t	+	ep +	4.033 (MeV)	-	$G_{\rm d} + G_{\rm p}$
5e	t+ep+4.174 (MeV)+ $G_{\rm p}$	$\rightarrow$	H^4	+	neutrino +	0.00 (MeV)		
	H^4	$\rightarrow$	t	+	n +	3.391 (MeV)		
5	t+ep	$\rightarrow$	He^4	+	e +	18.792 (MeV)	-	$G_{\rm p}$
6e	t+ed+5.318 (MeV)+$G_{\rm d}$	$\rightarrow$	H^5	+	neutrino +	0.00 (MeV)		
	H^5	$\rightarrow$	t	+	2n +	2.311 (MeV)		
6.1	t+ed	$\rightarrow$	He^5	+	e +	15.832 (MeV)	-	$G_{\rm d}$
	He^5	$\rightarrow$	He^4	+	n +	0.735 (MeV)		
6.2	t+ed+5.616 (MeV)+$G_{\rm d}$	$\rightarrow$	H^4	+	ep	0.00 (MeV)	+	$G_{\rm p}$
	H^4	$\rightarrow$	t	+	n+	3.391 (MeV)		
7	t(beta decay)	$\rightarrow$	He^3	+	e+antineut. (aver)	5.7 (keV)		
8e	He^3+ep	$\rightarrow$	He^4	+	neutrino+(max)	19.80 (MeV)		
9	He^3+ed	$\rightarrow$	He^4	+	ep + (max)	20.58 (MeV)		

(which is slower than the other interactions). These reactions will practically be relevant only when there are no alternatives that do not require the weak interaction.

- The reactions producing neutrons are all endothermic, apart form reaction 6.1, which requires tritium and deuteronius.
- If $G_{\rm p} > 1.442$ MeV reaction 1e is endothermic and no deuterium is produced without stimulation. This is very important because it would strongly differentiate between what happens with hydrogen and with deuterium loadings. Deuterium-loading allows the production of He^4 and tritium, and a high energy density if compared to the transmutations and the fissions to which a hydrogen-loaded system is limited. With hydrogen loading there would be no tritium production. The absence of deuterium and tritium in the ash of the tested E-Cat [9] seems to suggest that $G_{\rm p}$ is in fact higher than 1.442 keV, so that reaction 1e is actually endothermic.
- When He^4 is produced there is always a large energy release, as confirmed by experiments,
- Tritium is generated without the production of free neutrons: this explains the so-called "branching ratio anomaly".
- As already mentioned, when tritium is destroyed in presence of deuteronius (reaction 6.1), neutrons are actu-

ally produced, together with a large quantity of energy,

- If hydronius (ep) decomposes/decays, reaction 4.2 would be a source of protons/molecular hydrogen in experiments with deuterium loading.

8. The Nuclear Active Environment

If an External Core Orbital (which is the first orbital "below" the valence orbitals) with an energy not too far from the coupling energy gets exposed, it can turn into a NAE if a proton strikes it at the right energy. Typically ECOs can get more exposed by the presence of ionic bonds, which displace most of the charge density of the binding orbitals towards the electron acceptor.

In order to have a general idea of the energies of the ECOs of atoms it is possible to look at the ionization energies of the isolated atoms. The real energy of the ECO of a chemically bound atom will always be lower than the charted energy of the ECO of a free atom (ionization energy), because of the partial charge shielding of the valence electrons. However the energy difference between these two cases will decrease with the increasing "ionic" nature of the chemical bond.

By calculating the energy difference between the known ionization energies of all atoms and the coupling energy of 85 eV, it is possible to evaluate which atoms, if ionized (once or more), can offer naked orbitals that could more easily become NAE. Table 1 shows a summary of the atoms that have the energy of their ECO nearest to the coupling energy. The column "Complementary Energy" shows the difference between the ionization energies and the coupling energy.

From Table 1 it is interesting to note a series of points.

- The atomic ion with the ECO energy nearest to the coupling energy is Ca(IV). The energy of its ECO is only 0.5 (eV) from the coupling energy. However in common chemical conditions the maximum oxidation state of Ca is +2 so that Ca(IV) is not present in chemical compounds. The ECO energy of Ca(II) is at 34.09 (eV) distance from the coupling, therefore too much for any contribution from the diffusion of deuterons of Iwamura uses [11]. Instead a fraction of (eV) is an energy that the diffusing deuterium could reach. This suggests that in the multilayer of Iwamura there could be some calcium atom in a bound state that leaves the fifth orbital somehow "exposed".
- Zirconium, in common and stable chemical conditions, exposes an ECO which has the nearest energy to the coupling energy. The atom of zirconium in ZrO_2, while being well ionized (the Pauling electronegativity difference between oxygen and zirconium is 2.11), has an ECO energy of 80.35 (eV), only 4.65 (eV) from the coupling energy. Mitchell Swartz [7] uses ZrO_2 in his Nanor device. In that device the flow of deuterium is helped by a potential difference, which could account for the missing energy of 4.65 (eV). The protons could be in fact accelerated from one hydride grain to another crossing the ZrO_2 matrix.
- Magnesium should be similar to Zr because the ECO energy of Mg(II) is at only 4.9 (eV) from the coupling energy. Iwamura [11] tried this oxide, but did not obtain transmutations. One possible reason for this failure could be that his system cannot provide the deuterons with enough energy to reach the coupling.
- Yttrium was successfully used by Iwamura. This element has two non-ordinary oxidation states at ± 8 (eV) distance from the coupling energy. Their balanced linear combination would require a very low energy contribution from the moment of the deuteron.
- N(III) should have an ECO energy at 7.5 (eV) form the coupling, therefore it is another good candidate for a NAE.
- Li(I) has an ECO at about 9.4 (eV) from the coupling energy and is commonly stably "ionized" in this oxidation state. The missing energy is higher than in the Ca(IV), Zr(IV) and N(III) cases: 9.36 (eV). Lithium is a very good NAE because it can be a gas at the operating temperature of a hypothetical LENR reactor,

Table 1. Summary of the atoms that could have exposed ECO energies nearer to the coupling energy.

Reference experiment	Element	Ionization state	Ionization energy (eV)	Complementary energy (eV)	Ordinary oxidation state
Y. Iwamura	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
Leif Holmlid [10]	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"
Mitchell Swartz - NANOR	Zr	+4	80.35	4.65	yes
Y. Iwamura (not working)	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. Iwamura	Y	+5	93.00	–8.00	no
Y. Iwamura	Y	+4	77.00	8.00	no
	Ge	+4	93.5	–8.50	yes
A. Rossi	Ni	+4	76.06	8.94	yes
A. Rossi, H. Mills, Lipinsky, electrolysis	Li	+1	75.64	9.36	yes
	Mn	+5	95.60	–10.60	yes
	Sc	+3	73.49	11.51	yes

whereas all other NAEs are high melting point solids, in which only very thin surfaces near to the HNu source participate to the power generation. A gaseous NAE instead fills an entire volume and can undoubtedly offer higher power densities. Lithium has almost always been present in electrochemical LENR experiments. The cathode surface, before becoming “LENR active”, has to develop an oxidized layer with lithium, sufficiently thick as to build a potential difference that accelerates hydrogen nuclei allowing them to gain the missing energy.

9. Hydronion Accumulation inside Condensed Matter

The radius of the Hyd is 193 (fm), about 220 times the proton charge radius. This means that the maximum Hyd cross sectional area is about 50,000 times that of the proton. Moreover Hydronions have a large magnetic moment, essentially equal to that of the electron, which is about 960 times that of the neutron, the only other known long-lived neutral massive particle. Therefore inside condensed matter Hyd should be intensely magnetically scattered because the large magnetic moment and size of the Hyd should force it to interact with the orbital currents and with the intrinsic spin the electrons in the chemical structures it crosses much more intensely than the neutron. So Hyd produced inside condensed matter, if not enough energetic, could rapidly lose momentum and possibly end up trapped in the locations where the gradient of the magnetic field is higher (magnetic traps).

Hyd are neutral, so they interact only minimally with the chemical structure. However probably an extremely high density of Hyd would be able to modify the chemical properties of a substance. So far there are no reports showing change in the chemical properties of "LENR active" materials.

9.1. LENR explosions

Many LENR experimentalists have reported sudden melt down of working LENR active materials, and a number of explosions. As a matter of fact the whole Cold Fusion saga begun with an explosion in the laboratory of Fleischmann and Pons (see [12]). Explosions require a reaction that can involve the whole volume of the exploding material. In all experiments LENR seem to be happening on thin surfaces and not in the entire volume. This suggests that the origin of the volumetric reaction is the volumetric accumulation of a potentially nuclear-active particle. Evidences seem to suggest that this particle can be turned active by thermal and mechanical stimuli: phonons.

A possibility is that phonons, thanks to the magneto-phonon coupling, produce magnetic waves that push the Hyd out of the magnetic traps and force some of them to react. The reactions produce heat that generates a positive feedback that in turn can lead to an explosive outcome. So explosions and some types of runaways should be due to the accumulation of Hyd inside condensed matter followed by phonic stimulation.

9.2. Radio frequency emissions

A number of researchers reported radio frequency emissions (e.g. [13,14]). If the Hyd can end up trapped in condensed matter, they could be stimulated at the Larmor frequency (which is in the radio range for the Hyd) and undergo spin reversal. The following relaxation could be the origin of the radio frequency emissions, similarly to what happens in the Nuclear Magnetic Resonance technique.

10. Some General Remarks

10.1. Susceptibility to a magnetic field

Since the proposed EMNR mechanism is essentially magnetic, it should be susceptible to the presence of a magnetic field. The nature of the NAE could be an additional source of experimental susceptibility to a magnetic field.

10.2. Some nuclei do not react

As the Hot-Cat isotopic measurements show [9], some nuclei seem not react at all. The magnetic coupling in fact has a chance to take place only if a nucleus has a magnetic moment of first or higher order. Probably Ni^{62} does not have magnetic moments, due to its high symmetry. Ni^{62} has the highest binding energy per nucleon, and this should be due to a particularly high symmetry. If one accepts the isospin layered fcc model of the nucleus proposed by Norman Cook [1], the symmetric structure of Ni^{62} could be as shown in Fig. 3.

An additional reason for the inert nature of Ni^{62} is the fact that nuclear reactions inside the electron ZB take place at almost no excess kinetic energy, so that Ni^{62} cannot transform in to any other stable nucleus because there are no nuclei with a higher binding energy per nucleon.

10.3. No tritium accumulation

The magnetic moments of protium and tritium are higher than the magnetic moment of deuterium, in fact $m_{\mathrm{d}}/m_{\mathrm{p}} = 0.31$, $m_{\mathrm{t}}/m_{\mathrm{p}} = 1.07$. So the reactions with deuterium should be less favourite than those with protium and tritium. Here are summarized the reactions that generate tritium and that destroy it:

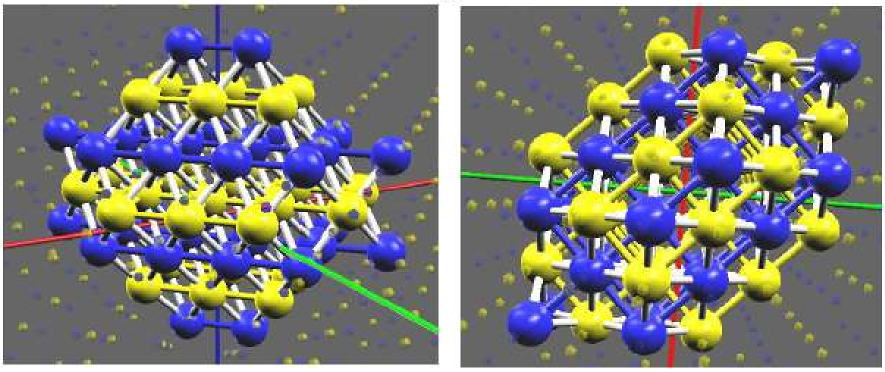

Figure 3. Possible symmetric structure of Ni^{62}.

Main source of tritium

$$4.2:\ \mathrm{d+ed} \rightarrow \mathrm{t + ep} + 4.033\ (\mathrm{MeV}) - G_{\mathrm{d}} + G_{\mathrm{p}}.$$

Tritium sink

$$5:\ \mathrm{t+ep} \rightarrow \mathrm{He}^4 + \mathrm{e} + 18.792\,(\mathrm{MeV}) - G_{\mathrm{p}}.$$

Since all reactions producing tritium (not only those above) involve deuterium, while the elimination of tritium involves protium, tritium should not accumulate. This should be the basic reason for the lack of accumulation of tritium and for its reported elimination apparently correlated to bursts of energy.

11. Summary of Relevant Features of the Proposed EMNR Theory

The proposed Electron-mediated Nuclear Reactions theory has the following fundamental features.

- The Coulomb barrier is not overcome kinetically.
- The nuclear binding energy is electromagnetic and, thanks to the mediation of the electron, a neutral pseudo-particle can form.
- EMNR take place in two stages:
  - *First stage:* Formation of the Hydronions.
  - *Second stage:* the "neutral" Hyd is captured by nuclei and fusion or fission take place "inside the electron".
- The reactions release nuclear energy in form of intense EUV radiation that readily transforms into thermal energy.
- When a Hyd couples to another nucleus it can cause both fusion and fission reactions.
- The preference for stable nuclei is qualitatively explained with the perturbation that the electron charge causes on the forming new nuclei.
- Tritium can be produced without neutrons (no branching ratio problem).
- The NAE is essentially an Electron Core Orbital with a relatively high energy near to 85 (eV) stricken by protons at energies in the (eV) range.

- The NAE is not inside the metal matrix.
- The most promising ECOs are those offered by Zr(IV) and Li(I). Probably, Iwamura managed somehow to use the ECO of Ca(IV), which is the nearest of all atoms to the coupling frequency, but it probably cannot offer a high NAE density.
- The measured radio frequencies emissions could be the "NMR" frequencies of the Hydronions trapped inside metal matrices.
- Biological transmutations are not impossible thanks to a series of ECO that are present in organic matter.
- The strange radiation has the features of the Hydronions.

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