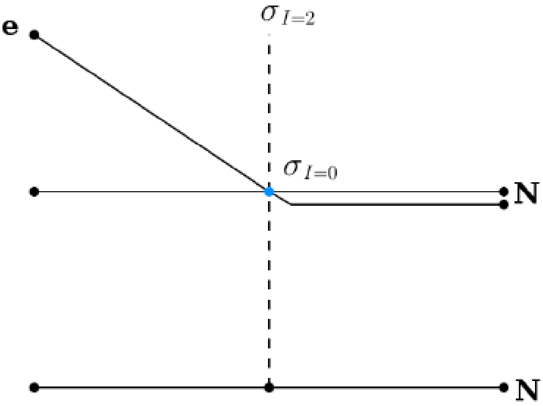
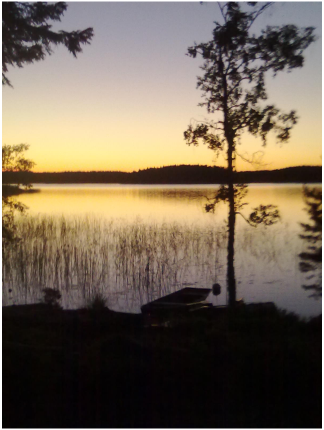
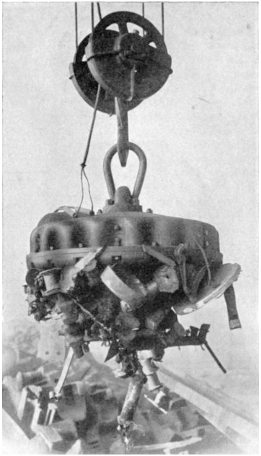
Working with theory about the Rossi effect



Invitation





- No strong magnets are found in nature. (on the surface of earth)
- Control current to enhance special strong directed magnetism in metals not found in nature.
- Control electrons to enhance special strong directed nucleon-nucleon force not found in nature.

"Low Energy Nuclear Reactions"

Problems to form a theory around:

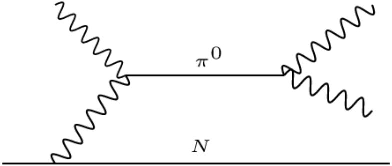
- No strong radiation. If no detection of strong radiation is found togheter with evidence of isotopic shifts ie the strong force, then everything that creates strong radiation must be forbidden and a theory is formed around what is left.
- The limited range of the strong force.
- Nuclides don't come close enough at room temperature to affect each other with the strong force.

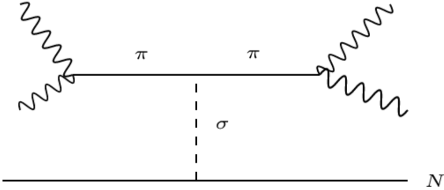
LENR

Solution presented here:

A new special potential of the strong force that is not found(common) in nature.

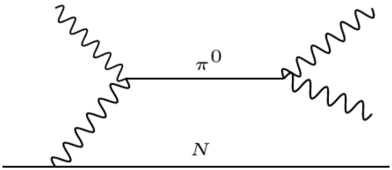
- Important feature is electron-nucleon interaction mediated by σ mesons.
- Releases energy continiuosly by slowly accelerate nuclides giving them kinetic energy.

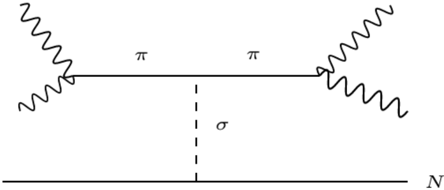




LENR

- The special potential is a strong force potential triggered by electrons. Hence it does not require long range nucleon-nucleon interaction as a start point.
- The special conditions that is not natural is that the electrons has to stay near(10^{-15} m scale) the nuclide for a long time while relative spin, velocity and space relation has to be comparable with binding condition of nucleon nucleon interaction.





Outline

- Main theory in 3 steps
- Short on other theories
- Experiment
- Comparision theory to experiment
- Future

Outline

The main theory is developed in three steps:

1. Develop a strong force potential for nucleon-nucleon(N-N) interaction with the no γ radiation as a requirement.
2. Enhance this potential by electron-σ meson interaction using isospin splitting of the σ meson in nucleons.
3. Use nucleon polarizability theory to establish the electron nucleon interaction properties based on electromagnetic field component in the interaction.

- Note: Our paper[1] has theory presented in opposite order.

[1] https://arxiv.org/abs/1703.05249

No γ problem for fusion

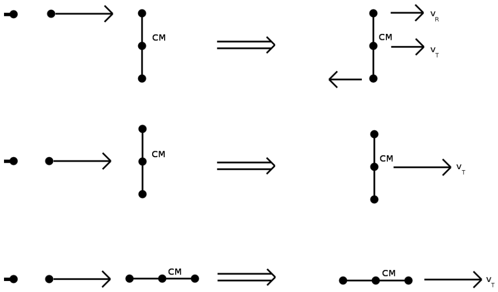
"cold fusion" is a bad word why? Because γ radiation needed for fusion reactions.

- Momentum and energy conservation can't be conserved in a pure $2 \to 1$ interaction (unless the sum of the initial momentum is 0).
- Normal fusion has an extra photon to carry away the extra momentum.
- Nucleon transfer reaction is a $2 \to 2$ body reaction. Energy and momentum is allowed to be conserved without extra particles.

No exited state for nucleon trasmission problem

Nucleon transmission reactions solves momentum conservation problem.

However just add a nucleon with a momentum transfer on a nuclide might create an oscillation motion unless the momentum transfer is applied on the center of mass.



No exited state for nucleon trasmittion problem

- Oscillation motion of nucleon inside nuclides=Exited states.
- Exited states in nuclides de-exites emitting strong radiation(most γ).
- Momentum transition to center of mass required for non exited state.

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Potential from requirement:

- Nucleon transfer reaction needed.
- Momentum transfer must be applied on center of mass on both nuclides.
- Attraction to Mass=Scalar term needed in attractive potential.

Strong force

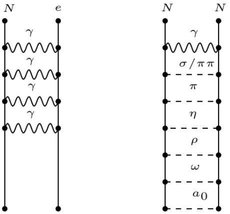
Theoretical need for LENR:

- Nucleon-nucleon interaction.
- Nucleon electromagnetic interaction i.e. nucleon-electron/photon interaction.

Energy range	fermion-boson (stable (∼point-)particle -interaction particle)	Type	Main experimental need
$\sim 1GeV >$	quark-gluon	Complete?	decay of hadrons/mesons
keV-MeV	baryon(nucleon)-meson	Effective	Nucleons in nuclides

- Mesons: 2 quark state separated by spin, charge, parity and quark generation(isospin:I,τ for generation 1).
- Baryons: 3 quark state Example:proton p($I = 1/2$), neutron n ($I = 1/2$) and DeltaΔ($I = 3/2$)
- Effective theories uses LEC's(low energy constant) to describe phenomena in a lower energy range. Many theories exist depending on choice of approximative formula and problem.

Strong force



Nucleon nucleon(N-N) interaction:

- Using complete quark-gluon theory has problem with fermion doubling problem. Also quark theory can't explain the absent of electric dipole moment of the proton and neutron.
- Nucleon nucleon interaction: Derived from meson exchange between nucleon. This is usually done as a trial function most succesfull theories fits constanst directly to r space operators.
- Both 2 and 3 nucleon interaction needed to explain all observations.

Strong force

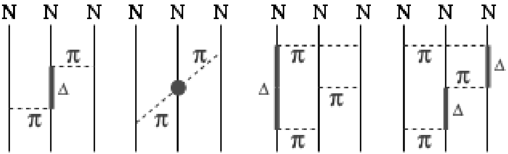
$$V_{L,S,I}(r) = \int \frac{d^3q}{(2\pi)^3} e^{iqr} \frac{g^2}{-q^2 - m^2} O(L,S,I) = -\frac{g^2}{4\pi}\frac{e^{-mr}}{r} O(L,S,I)$$

Meson	mass(MeV/c^2)	$I\,(J^P)$	role in N-N potential
π	138	$1\,(0^-)$	Classic long range
σ	550	$0\,(0^+)$	Binding(central+$L \cdot S$)
ω	782	$0\,(1^-)$	repulsive
ρ	770	$1\,(1^-)$	$L \cdot S$ interaction
a_0	980	$1\,(0^+)$	short range
η	548	$0\,(0^-)$	binding

Strong force

3 nucleon interaction:

- Internal structure change in the nucleon leads to different potential.
- Also the exchange particles interact in the space between two nucleons.



σ meson

- Scalar meson, scalar term=center of mass i.e. property of nucleon potential derived from no γ requirement.
- In effetive field theory: $\pi\pi$ s-wave resonance.
- Not natural long range. In one boson exchange potential(NN interaction usually change this term with one include a Δ):

$$V_{NN}^{(\sigma)}(r) = \int \frac{d^3q}{(2\pi)^3} e^{iqr} \frac{g_{\sigma NN}^2}{-q^2 - m_\sigma^2} = -\frac{g_{\sigma NN}^2}{4\pi} \frac{e^{-m_\sigma r}}{r}$$

with $m_\sigma \simeq 550$ MeV. Compare to EM potential from photon:

$$\frac{q}{4\pi} \frac{e^{-m_\gamma r}}{r}$$

with $m_\gamma = 0$.

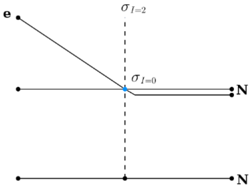
σ meson isospin

σ interaction properties: The σ meson is a phase shift in $\pi\pi$ scattering separated by isospin states.

- From $\pi\pi$ scattering[2]: $m_{\sigma_{I=0}} = 36.77 m_\pi^2$ and $m_{\sigma_{I=2}} = -21.62 m_\pi^2$
- Hadron interaction properties: Proton and neutron is isospin half state $\rightarrow m_\sigma$ in OBE potential is mixed: $m_\sigma = \sqrt{m_{\sigma_{I=0}}^2 - m_{\sigma_{I=2}}^2} = 543 \cong 550$
- Idea for step 2: electron-nucleon interaction enhance the range of the σ part of a N-N potential.

[2] G. Colangelo, J. Gasser, H. Leutwyler, $\pi\pi$ scattering, arxiv:hep-ph0103088v1

σ meson isospin



- Why? Electron is isospin 0 state interaction with $\sigma_{I=2}$ is suppresed compared to $\sigma_{I=0}$ which would increase the range of the σ part of the N-N potential.
- σ-electron interaction needs electron in nucleon since the interaction range of $\sigma_{I=0}$ is short.
- The σ-electron interaction doesn't equal a binding(by theory) therefore the electron must be kept in place by force.
- The electron must be able to spinflip(hyperfinestructure) to extract $\sigma_{I=0}$ energy out of the nucleon while stay in place.
- Hyperfinestructure interaction is in the energy range of meV while the potential need to absorb σ carried energy in the MeV range. This implies a long startup time.

Needed electron nucleon interaction

- Needed σ-electron interaction not complete yet by relative spin, velocity and space relation.
- If σ-electron interaction can't form bound states, the distance between electron and nucleon must be in the 10^{-15} m(fm) range.
- At a atomic level this means special condition in which the electron "stay" inside the nucleon.
- Electron nucleon intercation that would change the internal structure of the nucleon needed. So that the nucleon would correspond to a new bound state in another nuclide.

Nucleon polarizability

- What: Electromagnetic(EM) interaction of nucleon besides basic coulomb and magnet interaction i.e. internal structure changes.
- Compare to the 3 nucleon force where the internal structure changes affect the potential derived from the nucleon.
- Goal:Find EM interaction of e-N system that corresponds to binding condition of N-N force.
- Why? This would set the included nuclides in the new ground state binding condition after a nucleon transfer.
- Binding condition for particle systems are calculated by adding a negative term to the kinetic hamiltonian.
- Theoretical work have problems with choice of type of effective field approximation.

Nucleon polarizability

- Example coulomb interaction hamiltonian for atomic physics(V<0 electromagnetic binding):

$$H\Psi = E\Psi \to \left(-k\nabla^2 + V\right)\Psi = E\Psi$$

- Polarizability calculated in perturbation theory by adding effective hamiltonians that are divided according to spacetime derivatives(i) of the EM field

$$H = E_0 - \sum H_{eff}^{(i)}$$

- We look after conditions $H_{eff} > 0$.

Nucleon polarizability

Advance equations from perturbation theory[3]:

$$
\begin{aligned}
H_{eff}^{(2)} &= -\frac{1}{2}4\pi\left(\alpha_{E1}\bar{E}^2 + \beta_{M1}\bar{H}^2\right) \\
H_{eff}^{(3)} &= -\frac{1}{2}4\pi[\gamma_{E1E1}\bar{\sigma}\cdot\left(\bar{E}\times\dot{\bar{E}}\right) + \gamma_{M1M1}\bar{\sigma}\cdot\left(\bar{H}\times\dot{\bar{H}}\right) \\
&\quad -2\gamma_{M1E2}E_{ij}\sigma_i H_j + 2\gamma_{E1M2}H_{ij}\sigma_i E_j] \\
H_{eff}^{(4)} &= -\frac{1}{2}4\pi\left(\alpha_{E1\nu}\dot{\bar{E}}^{\,2} + \beta_{M1\nu}\dot{\bar{H}}^{\,2}\right) - \frac{1}{12}4\pi\left(\alpha_{E2}E_{ij}^2 + \beta_{M2}H_{ij}^2\right)
\end{aligned}
\tag{1}
$$

α_x, β_x, γ_x =polarizability constants.

σ = Pauli spin matrices of the nucleon

E and H are components of the electromagnetic fields.

$E_{ij} = \frac{1}{2}\left(\nabla_i E_j + \nabla_j E_i\right)$ (same for H_{ij})

Note: The third order perturbation is called spin polarizability and is not included in an classic static EM field.

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[3] F.Hagelstein, R.Miskimen and V.Pascalutsa, "Nucleon Polarizabilities: from Compton Scattering to Hydrogen Atom," Prog. Part. Nucl. Phys. bf 88 (2016) 29 [arXiv:1512.03765 [nucl-th]].

Values

Theoretical and experimental values of the proton and neutron static dipole, quadrupole and dispersive polarizabilities. The units are 10^{-4} fm^3 (dipole) and 10^{-4} fm^5 quadrupole.

	α_{E1}	β_{M1}	α_{E2}	β_{M2}
Proton				
BχPT Theory[4]	11.2 ± 0.7	3.9 ± 0.7	17.3 ± 3.9	-15.5 ± 3.5
Experiment(PDG[5])	11.2 ± 0.4	2.5 ± 0.4		
Neutron				
BχPT Theory	13.7 ± 3.1	4.6 ± 2.7	16.2 ± 3.7	-15.8 ± 3.6
Experiment(PDG)	11.8 ± 1.1	3.7 ± 1.2		

[4] V.Lensky and V.Pascalutsa, "Predictive powers of chiral perturbation theory in Compton scattering off protons," Eur. Phys. J. C 65 (2010) 195 [arXiv:0907.0451 [hep-ph]].

[5] C. Patrignani et al.(Particle Data Group), Chin. Phys. C, 40, 100001 (2016)

Values

Theoretical values of the proton and neutron static dispersive polarizabilities. The units are 10^{-4} fm^5.

	$\alpha_{E1\nu}$	$\beta_{M1\nu}$
Proton		
BχPT Theory	-1.3 ± 1.0	7.1 ± 2.5
Neutron		
BχPT Theory	0.1 ± 1.0	7.2 ± 2.5

Values

Theoretical and experimental values of the proton and neutron static spin polarizabilities. The units are $10^{-4}\ fm^4$.

	γ_{E1E1}	γ_{M1M1}	γ_{E1M2}	γ_{M1E2}
Proton				
BχPT Theory	-3.3 ± 0.8	2.9 ± 1.5	0.2 ± 0.2	1.1 ± 0.3
MAMI 2015[6]	-3.5 ± 1.2	3.16 ± 0.85	-0.7 ± 1.2	1.99 ± 0.29
Neutron				
BχPT Theory	-4.7 ± 1.1	2.9 ± 1.5	0.2 ± 0.2	1.6 ± 0.4

- Sign ofγ_{E1M2} visualize problem with different effective field theories:

$O\left(p^4\right)_b$	$O\left(\epsilon^3\right)$	$O\left(p^4\right)_a$	K-Matrix	HDPV
0.7	1.0	0.2	-1.8	-0.02
DR	L_X	HBχPT	BχPT	MAMI 2015
-0.02	-0.7	-0.4 ± 0.4	-0.2 ± 0.2	-0.7 ± 1.2

[6] P.P.Martel et al. [A2 Collaboration], "Measurements of Double-Polarized Compton Scattering Asymmetries and Extraction of the Proton Spin Polarizabilities," Phys. Rev.\Lett. 114 (2015) [arXiv:1408.1576 [nucl-ex]]

Polarizability binding conditions

- The $H_{eff} < 0$ condition has to be valid for the full equation, so that there can't be an extra E field if the B field condition is fullfilled plus the opposite.
- Define variable $x_{L,T} = \dot{\bar{E}}_{L,T}/\bar{E} \cdot \hat{\bar{E}}/\dot{\hat{\bar{E}}}$ to get two differential equations:

$$\alpha_{E1} \pm \gamma_{E1E1} x_T + \alpha_{E1\nu} x_T^2 \tag{2}$$

The $\pm$ sign is determined by the direction between the vectors $\bar{\sigma}$ and $\left(\bar{E} \times \dot{\bar{E}}\right)$.

$$\alpha_{E1} + \alpha_{E1\nu} x_L^2 \tag{3}$$

Polarizability binding conditions for electric field

Calculations for theoretical values from $B\chi PT$ gives the $H_{eff} > 0$ ranges:

Nucleon	$\text{sgn}\bar{\sigma} \cdot \left(\bar{E} \times \dot{\bar{E}}\right)$	$x = \dot{\bar{E}}/\bar{E}$ range (fm)
p	$+$	$x_T < -2$ $x_T > 4.5$
p	-	$x_T < -4.5$ $x_T > 2$
p	0	$x_L^2 > 0.11$
n	$+$	$3.1 < x_T < 44$
n	-	$-44 < x_T < -3.1$
n	0	-

Polarizability binding conditions for magnetic field

- $\beta_{M2} < 0$ gives $H_{eff} > 0$ at a center of magnetic quadrupole.

For combined electric and magnetic fields define $x = \sigma_i E_j / H_{ij}$ and E_j as $Esin\theta$ (with θ the angle between dimension j and the plane defined by i and k). This gives the second order equation:

$$\beta_{M2}/6 + 2sin\theta\gamma_{E1M2}x + x^2\alpha_{E1} \tag{4}$$

x=0 always gives $H_{eff} > 0$ values. The relation to have H_{eff} values with different sign are given by::

$$\frac{6\gamma_{E1M2}^2}{\beta_{M2}} sin^2\theta = \alpha_{E1} \tag{5}$$

$H_{eff} > 0$

The three conditions for $H_{eff} > 0$:

- A center of a magnetic quadrupole which also allows for a weak electric field.
- Two ranges from the parameter $\dot{\bar{E}}_{L,T}/\bar{E}$:
- The $x_L^2 > 0.11$ range has $\dot{\bar{E}}$ in the direction of $\bar{E}$.
- The x_T ranges has $\dot{\bar{E}}$ perpendicular to $\bar{E}$, this means a circular motion of the electron around the nucleon.

Atomic states

- Combine the short range need from the $\sigma_{I=0}$ mass with the spin polarizabilities yields special conditions on the nucleon electron relation.
- The energy gets released by accesing the σ meson part of the nucelon by polarizability relations and sent away by classic electromagnetic interaction.
- Due to the long range that the new potential is suppose to have, the electron has to have a stable position near the nuclide(in the fm range).
- Only atomic binding to have elctron at nuclide is s-state atomic bindings however average distance is in the order of 10^{10} m.
- Solutions:

1. Pressure would make the electron come closer to the nucleon.
2. The nuclides create a positive ion current that follows an electron current.

Atomic states

- The x_L solution can't be combined with the long time requirement since the interaction is a linear motion.
- The magnetic quadrupole solution is compatibale with both solution 1 and 2.
- The x_T solution could be combined with solution 1 and 2 in special conditions:

1. Non s-state atomic binding would need extreme pressure to fullfill the range condition. For a s-state element the electron nuclide relation is approximately a rotation if the center of mass does not equal the center of charge. However the nucleon spin is in s-state perpendicular to the $\left(\bar{E} \times \dot{\bar{E}}\right)$ vector not aligned. The solution is to have an electron that transforms between a state with aligned nucleon spin and near nucleus condition. The right conditions are found for s-d_{z^2} overlaps.
2. For nucleon current that follows electron current the nucleon spin must precise around the electron.

Other theories

New particle theories:

- Dark matter theories.
- Low energy virtual particles theory. I and Rossi are also making the hypothesis of the possibility that the temperatures of the plasma can reach the mass of , waves in fields that could annihilate without emitting high energy radiations because of the low energy.

Problem: Strong evidence of isotopic shifts requires link to the strong force at some point.

- Multi particle binding would explain the no γ condition with binding a lot of particles to the nucleon instead of one.

Problem: Electromagnet interaction strongly enhance one photon couplings.

Experiment

Observations[7][8][9]:

- Energy production without strong radiation.
- Isotopic shifts
- Positive ion current

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[7] http://www.elforsk.se/Global/Omv%C3%A4rld_system/filer/LuganoReportSubmi

[8] K. A. Alabin, S. N. Andreev, A. G. Parkhomov. Results of Analyses of the Isotopic and Elemental Composition of Nickel- Hydrogen Fuel Reactors. https://drive.google.com/file/d/0B5Pc25a4cOM2cHBha0RLbUo5ZVU/view

[9] https://arxiv.org/abs/1703.05249

No γ radiation

- Observed: Gamma radiation less than background level.
- For a detector ~ 0.5 m away this means $10^4 - 10^6$ γ/s for γ energies ~100 keV to ~10 MeV.
- Observed: $10^{12} - 10^{15}$ transfer reactions/s. If each reaction creates ~ 1 MeV of energy.
- Creation of some radioactive nuclides that almost does not produce γ radiation still possible.
- Example:

^6He:$\sim 10^{12}$ produced/s possible, above this secondary x-ray from β^- radiation should be detectable.
^{59}Ni:$\sim 10^{20}$ produced/s possible. Above this rate 511 keV γ rays from positron annihilation should be at background level.

Isotopic shifts

Main detected isotopic shifts:

$$^{62-x}Ni + xn^* \rightarrow ^{62} Ni$$

$$^{27}Al + p^* \rightarrow ^{28} Si$$

$$^{y-x}Ni + xn^* \rightarrow ^{y} Ni$$

where p^* and n^* mean a bound nucleon. Also possible observed is:

$$^{7}Li + p^* \rightarrow ^{8} Be \rightarrow 2\alpha$$

(If p is a free proton this would create measurable γ radiation above background level but not with bound)

Isotopic shifts

Neutron sources:

$$^{64}Ni \rightarrow ^{62}Ni + 2n^*$$

$$^{7}Li \rightarrow ^{6}Li + n^*$$

Proton sources:

$$^{7}Li \rightarrow \,^{6}He + p^*$$

$$^{55}Mn \rightarrow ^{54}Cr + p^*$$

- Note that the transmitted nucleon has to be absorbed into a lower energy state i.e. isotopic shifts only happens for energy release reactions.

Positive ion current

New experimental observation: Li/H ratio in plasma is related to output energy.

Output power is created when negative ions changes to positive ion kinetic energy.

Neutral plasma$\rightarrow$ number and speed of positive and negative ions that enters the plasma are the same.

COP: Kinetic energy of positive ions/kinetic energy of negative ions.

Non relativistic kinetic energy:

$$\sum \frac{m_+ v_+^2}{2} / \sum \frac{m_- v_-^2}{2}$$

- Neutral plasma gives:$\sum v_+^2 = \sum v_-^2$
- COP is related to m_+/m_- i.e. in the range $m_{Li}/m_e = 14000$ to $m_H/m_e = 2000$.
- Measured COP in the doral test are in the range of thousands. Li/H ratio are reduced with the COP.

Important atomic states

Experimental observation of needed elements is in agreement with the theoretical requirement of atomic states.

- Free s-state electron elementens needed to have spin flip electrons in nucleon.
- Free d_{z^2} electron elements needed to have nucleon spin perpendicular to electron.
- d_{z^2}-s overlap needed

d_{z^2} electron elements:

- Nickel group i.e. Nickel, Palladium, Platinum.

Free s-state electron elements:

- Hydrogen
- Alkalimetals:Lithium, Sodium, Potassium, Cesium.
- Some other metals: nickel, platinum, niobium, molybdenum, ruthenium, rhodium, and chromium.

Experiment-theory comparision summation

- No strong radiation $\rightarrow$ continiuos kinetic energy release of nuclides.
- (No γ)Momentum transfer is applied on center of mass $\rightarrow$ potential is mediated by scalar meson(σ)
- Long range σ potential not natural. Created by special electron-nucleon interaction.
- One electron in s-state elements are needed:spin flip electron in the nucleon needed.
- One free electron in d_{z^2} shell elements needed: Tilt electron in right position compares to binding condition of polarizability.
- Plasma between Ni rods: Nickel creates $\sigma_{l=2}$ potential that drags protons and Lithium ions through air.

Future

Experimental to do:

- Important atomic states must be examined better. For example by doing isotopic shift measurement in slices.
- Measure a start time for the reaction to compare the meV spinflip interaction to the MeV nucleon transfer reaction.
- Find evidence for more possible isotopic shifts.
- Take α/β radiation spectrum to fit to theory.
- Exact numbers of output power compared to H/Li ratio in plasma.
- Hydrogen in plasma. Free hydrogen or proton in a long range nucleon transfer reaction?(would be possible to measure by the mass of the proton)

Not LENR experiment:

- Better polarizability measurement to confirm the theoretical values.

Future

Theoretical to do:

- More exact theory for electron-σ interaction needed.
- Theory for multinucleus transfer reactions. Especially α clusters.(Deuteron-Palladium systems)
- Detailed study of available atomic states.
- A unified theory for the effective theory range of the strong force. Fermion doubling problem needs to be solved for this(I know a solution but it isa long proof).