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Muon-Surrogate Catalyzed Fusion Interpretation Of Steinetz-Benyo Transmutations Stimulated By Gamma Rays

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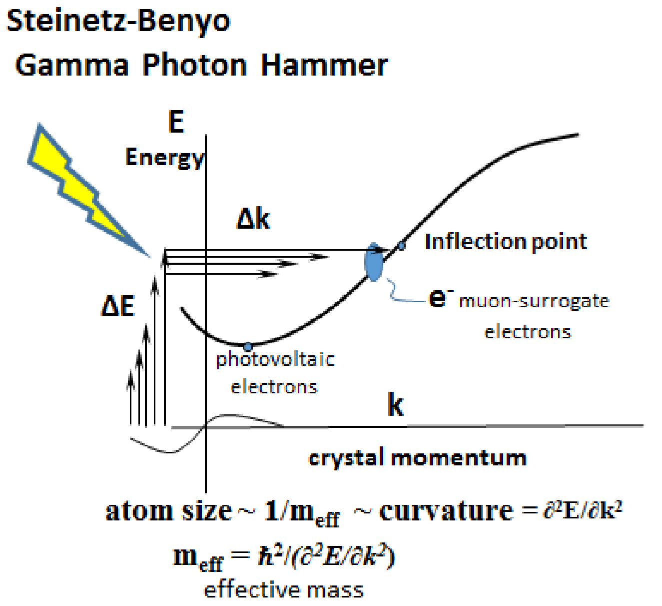
Steinetz et al observed a reaction energized by nominal 2 MeV gamma rays that produced some neutrons with energies greater than 10 MeV and beta emitters that appear to be transmutation products. Their observations appear to be predictable using recently discovered chemical physics, first to create muon-surrogates in nano-crystallites, which mimic muon catalyzed fusion, and second using direct vibrational to electron quasiparticle energy conversion. Together they concentrate nearly all the nuclear binding energy into heavy electron quasiparticles. Heavy electron generation producing muon-surrogates here would use a process almost identical to photovoltaic energy conversion in indirect semiconductors, such as silicon, but with MeV rather than eV photons.

Gamma photon as a photovoltaic

Steinetz et al recently observed highly energetic, some more than 10 MeV neutrons, and multiple different radioactive beta emitters, all created at ambient conditions. However, their stimulation energy, a nominal 2 MeV energetic gamma ray, was deliberately chosen to be too little to dislodge the neutron from the deuterium used as a hydride for erbium, hafnium and molybdenum (Er, Hf, Mo) targets.



Band Structure Diagram, showing simultaneous crystal momentum and energy injection in a chemical using a gamma photon with wavelength much smaller than the dimension of the unit cell. The photon energizes a range or splatter of electron energies and crystal momenta across the first few Brillouin zones, some covering a range near the inflection point where the electron effective mass rises to values useful for Alvarez-type muon catalyzed transmutations.

The momentum in the energetic gamma could impart sufficient crystal momentum to create a local, transient distribution of heavy electrons. The process is quite similar to visible light generating photovoltaic electrons in an indirect semiconductor like silicon. The gamma colliding with a crystal nucleus simultaneously adds both a splatter of electron energies and, uniquely, a splatter of short wave length crystal momentum waves to the ions in the immediate collision path of the gamma ray. When the splatter of electron energy and crystal momentum overlaps a region near an inflection point of the band structure (E vs k), the effective mass of the electron becomes many times larger, and only for a period of about 10 femtoseconds. A small, localized, transient, non-zero distribution of heavy electrons is the result (m_{se}, muon surrogate electrons).

A heavy electron was the only requirement for a muon catalyzed cold fusion reaction Louis Alvarez designed and observed in 1956. He published it with title “Catalysis of nuclear reactions by mu mesons.” It continues today as “muon catalyzed fusion.” Alvarez could only rely on one mu meson at a time (now renamed “muons”). Steinetz gamma can produce a useful density of muon-surrogates in and around the nuclei, with data suggesting more than 6 muon surrogates per nucleus.

Using the recently discovered direct vibration to electron energy conversion (LaRue et al, J. Phys. Chem. A 2011, 115, 14306–14314), we “predicted” which isotopes of Er, Hf and Mo would react. We considered transmutations between deuterons and reactants where both deuterons and the reactants Er, Hf and Mo are attracted to muon-surrogates (m_{se}) between them. Note carefully: “between them.” The direct conversion reaction energizes and places the reactants inside the nucleus in an unusual state where they are almost-dissociated (Rydberg state)--prime for nucleon rearrangement. These reactions release a comparatively large energy, typically 20+ MeV, to deuterons and electron quasiparticles ***inside the nucleus***. The 20 MeV is more than enough to dislodge a neutron from a proton attracted to it, typically only bound by about 6 MeV. The energy rearranges the nucleons. One result is a prediction of neutrons with a fraction of 20 MeV energy and a creation of radioactive beta emitters (nuclei with one or more too many neutrons).

The missing reactions were also predicted, such as “no reaction” when hydrogen (protons) comprised the chemical hydrides instead of deuterons. There is a minimum effective mass associated with each reaction. The effective mass must be heavy enough to permit accessing a second vibrational inner turning point inside the range of nuclear vibrations. The first inner turning point is the familiar chemical one. The second is forbidden by a quantum confinement energy barrier.

One prediction is that the minimum electron effective mass to stimulate the reaction was “difficult” with hydrogen, requiring about 20 electron masses, and “easier” with deuterons, requiring typically between 5 and 8 electron masses. Further, the reactants they (deliberately?) chose permit many different deuteron attraction reactions and only a few proton attraction reactions.

Analyzing Steinetz data allowed us to test a two-step, autocatalytic reaction inside the nucleus. We were able to predict the observed Steinetz neutron energy range and the creation of beta emitters. Using the same proposed process as a clue, we were surprised to be able to “predict” the proclaimed and completely enigmatic proton-nickel reaction isotopes, which included puzzling iron, cobalt and zinc.

The Steinetz-Benyo observations are a unique confirmation of the combination of two new discoveries: “direct vibration to electron energy transfer” and “creation of heavy electrons by simultaneous, collocated crystal momentum and electron energy addition.”

Details

By using a 1.4-2.6 MeV gamma ray as the stimulator, they energize a splatter of both electron energies and crystal momenta. When the gamma ray encounters an atom it “hammers” both the electrons and ions. The momentum and energy effects are felt within a unit crystal. The gamma ray wavelength (~ 1E-12 meters) is much less than the atom spacing (~ 300 E-12 meters). Such a short wavelength promotes a crystal momentum splatter with wavelengths that are biased to cover the first Brillouin zone, including its many inflection points.

Both energy and crystal momentum are added simultaneously at the same location. Notice that if the energy and momentum were smaller, such as from visible light (~2 eV), the result would be a photovoltaic process in an indirect semiconductor, where thermal fluctuations must provide the missing crystal momentum.

Because the gamma has an energy far above the highest energy electron in an atom (K-alpha) the gamma penetrates deep relative to the more familiar, surface initiators. Only the surface is accessed using the more familiar ways to inject crystal momentum and energy. More familiar are adsorption, desorption and particle injection, such as glow discharge (Karabut, Russia), deuterium gas adsorption (Iwamura, Japan), atomic hydrogen flux (Dufour, Moller), and electrolysis. Steinetz therefore uniquely accessed the entire volume of the chemical.

Every element Steinetz included in their target mix had a strong mass-energy potential difference for deuteron-nucleus fusion/transmutation reactions (energy ~ mass defect). Almost none of the Steinetz nuclei have a positive (energy emitting) mass defect for proton or deuteron-nuclei fusions. Each element is in the tri-particle configuration typical of this reaction, as in an H_2^+ ion, where a fuel (protons, deuterons, tritons) interact with a common reactant (Er, Hf, Mo), and are attracted to heavy electrons (m_{se}) **between** them. These strongly resemble Iwamura-type, state transition reactions.

d m_{se} Er m_{se} d → Ytterbium, ~ 20 MeV (mse ~ 6 m_e)
d ms_e Hf m_{se} d → Tungsten, ~ 20 MeV (mse ~ 6 m_e)
d m_{se} Mo m_{se} d → Ruthenium, ~ 20 MeV (mse ~ 8 m_e)
d m_{se} C m_{se} d → Oxygen, ~31 MeV (mse ~ 32 m_e)
d m_{se} O m_{se} d → Neon ~ 20 MeV (mse ~ 27 m_e)

Each combination above should react. Steinentz apparently did not know about the minimum effective mass requirement. Effective mass limitations also explain the lack of hydrogen reaction signatures. For the deuterium reactions the effective masses need to be at least in the range from about 5 to about 8 electron masses. For the sparse few proton reactions allowed, the effective mass needs to be above about 20 or 30. Achieving minimum effective mass for deuteron reactions was far easier and more probable to achieve than for protons.

Steinetz documented posttest gamma spectra evidence of radioisotopes:

- erbium (^{163}Er and ^{171}Er)
- molybdenum (99Mo and 101Mo)
- by beta decay, technetium (99mTc and 101Tc)
- radioisotopes of hafnium (180mHf and 181Hf)
- molybdenum (99Mo and 101Mo),
- by beta decay, technetium (99mTc and 101Tc)
- energetic neutrons (some > 10 MeV)

The key to understanding the trace energetic neutrons and creation of beta emitters is the result of asking the question:

> What happens when one directly injects both 20 MeV
> and negatively charged m_{se} *inside the nucleus?*

A two-step process could explain the observations. This is familiar to chemistry as “autocatalytic reactions.” First, a ***“driver reaction”*** injects many MeV energy directly inside the nucleus in the form of energetic protons and/or deuterons, and energizes m_{se} with sufficient energy to eject from the product nucleus, using direct vibration to electron energy conversion. Second, a ***“consequence reaction”*** other than ejection becomes allowed and probable, such as collisions between the fuels (protons, deuterons, tritons) and reactant nuclei protons and neutrons ***inside the nucleus.***

Example: 2 d, 2 mse Erbium Driver Reactions

fuel(s)	reactant	product	**Energy MeV**	m_eff threshold
2 d	erbium_164	ytterbium_168	**21.9**	6.2
2 d	erbium_166	ytterbium_170	**22.1**	6.1
2 d	erbium_167	ytterbium_171	**22.3**	4.6
2 d	erbium_168	ytterbium_172	**22.5**	4.6
2 d	erbium_170	ytterbium_174	**23.1**	4.9

Example Consequence Reactions

Autocatalytic Trace Neutron Generation Reactions

(autocatalysis creates an intermediate in a first reaction and then consumes it in a second reaction. The intermediate can therefore be difficult to observe).

fuel	reactant	product	**Energy MeV**	m_eff threshold
2 d	erbium_164	ytterbium_168	**21.9**	6.2
21.9 MeV +2 mse	ytterbium_168	Erbium-163 + He + n	**15.0**	

The driver is 2d 2mse erbium_164 to give Ytterbium_168, yielding 21.9 MeV inside the nucleus. An energetic deuteron is attached to a proton, and the deuteron is attracted to the erbium and slams into a neutron in the nucleus, knocking it out and leaving a beta-emitter, Er_163, and helium.

fuel	reactant	product	**Energy MeV**	m_eff threshold
2 d	erbium_167	ytterbium_171	**22.3**	4.6
22.3 MeV +2 mse	ytterbium_171	ytterbium_170 plus neutron	**15.7**	

Autocatalytic Beta Emitter Reactions

fuel	reactant	product	Energy MeV	m_eff
2 d	erbium_170	ytterbium_174	23.1	4.9
23.1 MeV +2 mse	ytterbium_174	erbium_171+He^3	9.0	

fuel	reactant	product	Energy MeV	m_eff
2 d	molybdenum_92	ruthenium_96	25.5	8.8
25.5 MeV +2 mse	ruthenium_96	technetium_93 +tritium	8.1	

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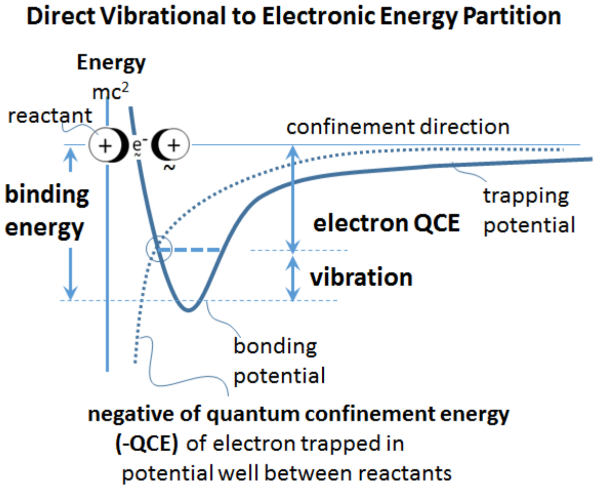
arXiv:1704.00694 Steinetz, Benyo et al. using Er, Hf, Mo and 2 MeV Gamma x-ray
arXiv:1704.01183 Benyo et al. using Ti and ~ 0.2 MeV x-ray

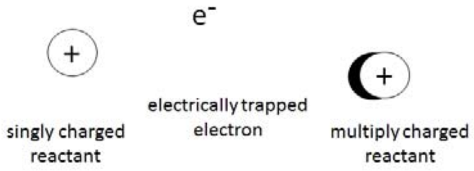
Direct Vibration to Electronic Energy Conversion

This reaction mechanically energizes an electron into an unfamiliar form. The form is “quantum confinement energy” (QCE). According to the Heisenberg Uncertainty Principle, QCE is the energy that must be supplied to confine and squeeze any matter or wave into or within a boundary. An electron is placed between two electron-attracting reactants, confining and trapping it to within the quantum well of the molecular boundary. When the reactants are nuclei, their mutual repulsion is weaker than their attraction to the electron between them, so they would converge without limit. Note “between them,” indicating the bonding wavefunction, not the anti-bonding.



Chemical physics has known for a century that QCE is a repulsive energy preventing such collapse. This is the classic H_2^+ ion of chemistry. “QCE” is the trapped muon-surrogate electron’s “T” term, in the Hamiltonian H=T+V.

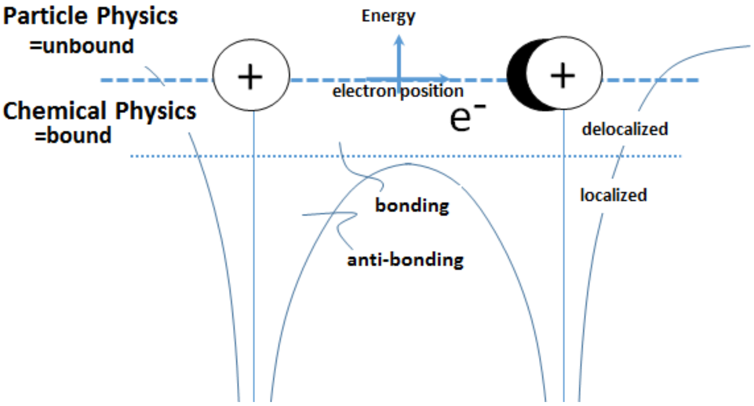
Some particle physicists strongly assert that “coulomb repulsion” dominates. More than a century ago, one of the first and greatest achievements of quantum mechanics was to explain why all matter did not collapse to nuclear densities. A century ago, simple physics showed real chemicals are characterized by coulomb attraction, not coulomb repulsion. Holding off fusion, there is a barrier, but not a coulomb barrier.



Tri-body basic reaction in its initial, Rydberg state, a singly charged nucleus and a multiply charged nucleus “far apart” and electrically bound together by the nearly free electron. The transmutation to a new nucleus will be attractive when the reactants weigh more than the product nucleus. The E=mc² mass-energy difference, “the mass defect,” is the energy source.

Cold fusion of two positive nuclei is never bound, is statistically impossible and cannot happen. Consistent as well with the “direct vibration to the electron energy conversion” discovery, two-body coulomb repulsion is completely confirmed, and cold fusion of two nuclei is impossible. Here we are describing three-body attraction reactions.

Chemical physics has known for a century that particles in real matter do not have enough energy to eject from the real chemical. In contrast, in particle physics experiments, an energetic particle (energy greater than work function and greater than ionization or dissociation energy) impinging on a foil target is not bound, and therefore coulomb repulsion applies. When no particle in the real chemical has that minimum energy, the system has a net negative potential, has no net coulomb repulsion, and should attract itself to nuclear dimensions. Wolfgang Pauli and Werner Heisenberg asserted why quantum confinement energy is the only repulsive “force” resisting coulomb collapse in real chemicals, which are “completely bound.”



Transient, muon-like elevated effective mass electron quasi-particles and the 1990’s discovery of direct vibration to electron energy conversion is the cause of this disruption. The muon catalyzed fusions are well-known as cold transmutations. They are all of the three-body type. The attraction energy can become concentrated in the QCE of the confined muon-like heavy electrons, leaving little or no energy for the familiar nuclear branching reactions. Details are in a companion document, tentatively titled “Muon-surrogate Catalyzed Transmutations Of Radioactive Waste Using Recently Discovered Direct Vibrational To Electron Energy Transfer And Transient, Elevated Effective Mass Electron Quasiparticles” (Zuppero-Dolan 2017-06-23)

Isotope reactions
(“predicted” in this exercise)

2d 2m_{se} Erbium …Steinetz
2d 2m_{se} Hafnium…Steinetz
2d 2m_{se} molybdenum…Steinetz
2d 2m_{se} titanium … Benyo
(producing beta emitters and trace, energetic neutrons)

p m_{se} and 2p 2m_{se} Nickel …Bazhutov-2014
(producing copper, zinc, cobalt, iron)

Transmutation reactions
(observed and “predicted” by muon-surrogate, direct vibration to electron energy conversion, tri-body attraction reactions)

p and 2p Nickel to Cu, Zn, Fe, Co …Bazhutov-2014, Italy (U. Padua) m* ~33 (m_{se} threshold)
p Rb^{85} to Sr^{86} …Bush USA 1994 m*~21
4d Cesium to Pr^{141} …Iwamura m* ~5
4d Strontium … Iwamura m* ~8
6d Barium … Iwamura m* ~8
2d calcium-44 … Iwamura m* ~8
2d tungsten … Iwamura, Moller m* ~6
4d tungsten .. Iwamura, Moller m* ~6

stable isotopes --- LENR evidence, using estimated m_{se} densities ~ cube of m*, expect as many as ~ 100 mse per nucleus

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