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In September 1924 Nagaoka transmuted Tungsten into Gold via electric arcs

Was perhaps most famous physicist in Japan at that time

Internationally recognized as competitor of Rutherford

Early in 1925: retired at age 60 as Tokyo Univ. Prof. of Physics; went to RIKEN

June 1925: traveled around world showing-off specimens of produced Gold

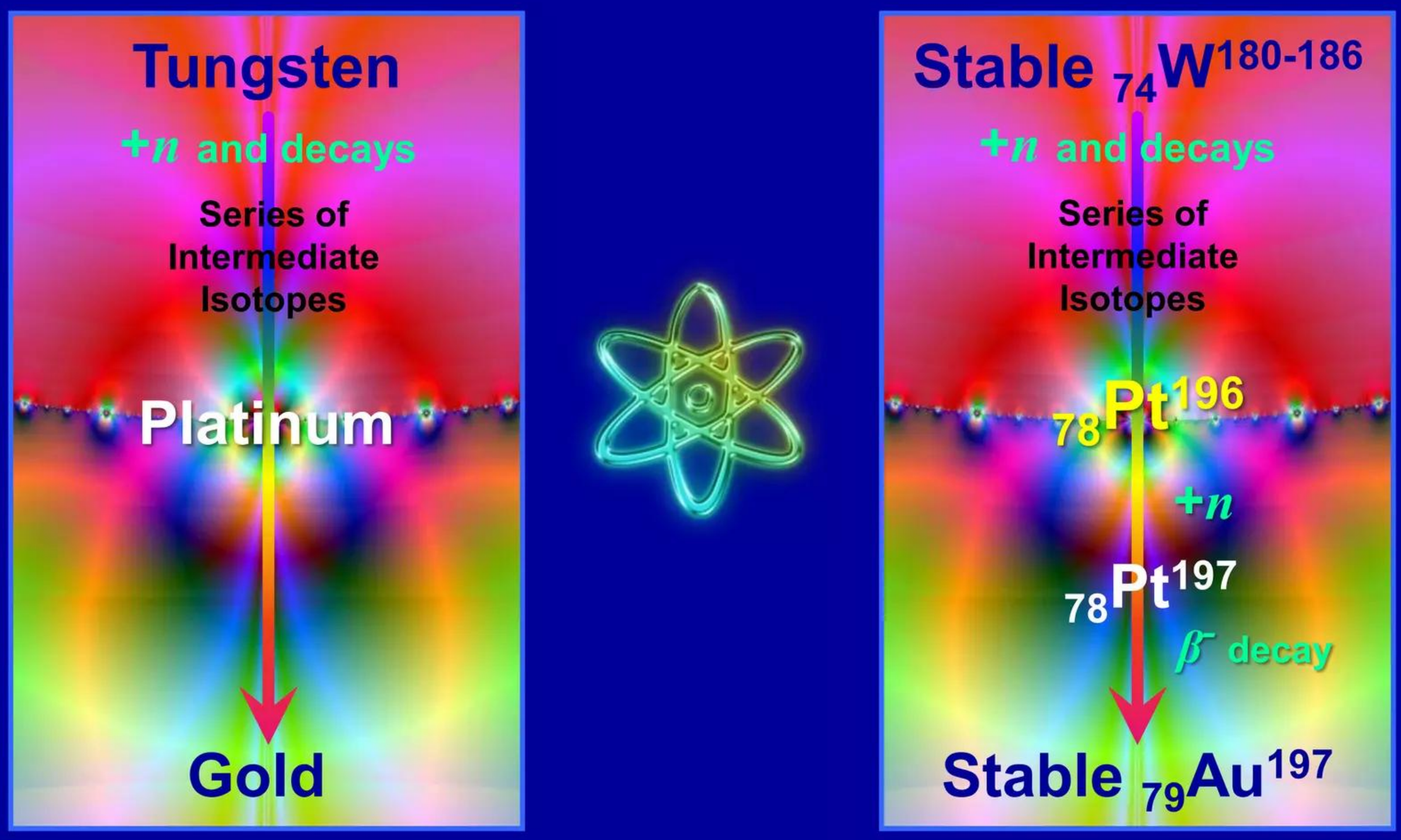
July 1925: his *Letter to the Editors* of British journal *Nature* was published

1926 - 1930: published on exploding wires and Au/Hg/Tl spectroscopy

1931: was appointed as 1st President of Osaka Imperial University

Why did electric arc work stop by 1930?

Widom-Larsen theory of LENRs explains Nagaoka's results



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Transmutations were a hot topic in 1920s

Many famous scientists pursued electric discharges

> "The [high-current electric arc] experimental procedure here sketched cannot be looked upon as the only one for effecting transmutation [of other elements into Gold]; probably different processes will be developed and finally lead to industrial enterprises.
>
> Experiments with various elements may lead to different transmutations, which will be of significance to science and industry. Meagre as is the result, I wish to invite the attention of those interested in the subject so that they may repeat the experiment with more powerful means than are available in the Far East."
>
> Prof. Hantaro Nagaoka
> "Letters to the Editor," *Nature*, July 18, 1925

Transmutations were not considered fringe science during the early 1920s. *Au contraire*, there was a very lively back-and-forth global dialogue on the subject involving some of the most famous physical scientists of that era. For example, in a *Scribner's* magazine article published in 1923, Prof. Robert Millikan (U. of Chicago, Nobel prize in physics, 1923) said, "As early as 1912, Dr. Winchester and I thought we had good evidence that we were knocking hydrogen out of aluminum and other metals by very powerful electric discharges in vacuo … How much farther can we go in this artificial transmutation of elements? This is one of the supremely interesting problems of modern physics upon which we are all assiduously working." [at that point Millikan was busy setting-up a high voltage laboratory at Caltech to test those ideas]

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1925 - 1930s: Nagaoka was a towering figure

During interview by John Wheeler in 1962, Hideki Yukawa (1949 Nobel Prize in physics for contributions to meson theory) commented on Nagaoka's power and influence

Source: http://www.aip.org/history/ohilist/868.html

Yukawa: "I can check it. I think this is about 1931 or '32. But this was not the first. We were very fortunate. There were many European physicists who visited Japan and came to Kyoto University … when I was still a student, and he [Laporte] talked about new quantum mechanics. And then came Sommerfeld. And then came Heisenberg and Dirac too, and a few years later came Bohr."

Wheeler: "Who took the initiative in inviting these people to Japan?"

Yukawa: "I think Professor Nagaoka was all powerful then among scientists … he had some very deep insight, although he did not work himself [at that point in his career] … Nagaoka was [the] President of Osaka University when I moved from Kyoto to Osaka. But he was at the same time President of the Academy; he was the greatest boss among all the scientists in Japan. Although he was perhaps over sixty, he was mentally very young. And he was interested in new physics, and he tried to invite the first-rate theoretical physicists from abroad … and he tried to invite these foremost physicists to Kyoto University too. So we were very fortunate to have the opportunity to listen to lectures by these first-rate, eminent theoretical physicists from abroad. And then, after that, we were also fortunate that Japanese physicists who had been studying in Europe" [which included Nagaoka]."

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1900 - 2013: selective timeline of events

- **Early 1900s:** many researchers reported transmutation of elements during electric discharges; no theoretical explanation of data existed
- **1922:** Wendt & Irion reported producing Helium in exploding wires; Rutherford trashed their results and effectively ended their careers
- **1925:** Nagaoka reported producing Gold during electric arc discharges and encouraged others to verify it; few believed his spectacular results
- **1927:** one of Millikan's PhD students reported arc-driven heavy element transmutations in *Physical Review*; not widely believed by physicists
- **1932:** Chadwick first confirmed the existence of Rutherford's "neutron"
- **1938:** Hahn & Strassman - first experimental report of Uranium fission
- **Early 1930s to 1950:** dark ages of electric arc research; few pursued it anywhere except for Paneth who fled to England from Germany in 1933
- **1951:** Sternglass saw neutron production in arc discharges; consulted Bethe & Einstein; dropped work because he wanted to get PhD quickly
- **1957:** modern astrophysical ideas about nucleosynthesis of elements in stars delineated in famous paper by both Burbidges, Fowler, and Hoyle
- **1989:** Pons & Fleischmann claimed that D+D "cold fusion" was seen in D_2O electrolytic cells; research was trashed by mainstream scientists
- **2002:** Mitsubishi Heavy Industries reported transmutation of Cesium to Praseodymium in refereed journal; results questioned by some parties
- **2006:** Widom & Larsen published collective many-body weak $e + p \rightarrow n + \nu$ theory of LENRs in peer-reviewed *European Physical Journal C*
- **2012:** At ANS, Mitsubishi Heavy Industries confirmed Nagaoka's LENR transmutation pathway of Tungsten → Osmium → Platinum → Gold
- **2013:** Toyota finally confirmed Mitsubishi's D_2 permeation method for W-L LENR transmutation of stable Cesium → stable Praseodymium

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Much was still undiscovered in 1924-26

Transmutation processes are well-understood today

- ✓ To understand why some in the world of science may have reacted to Nagaoka's reported results with quiet skepticism, one must appreciate how little was known back in the early 1920s compared to today's vast increases in knowledge
- ✓ Although Rutherford had hypothesized the existence of an electrically charge-neutral nuclear particle that we now call the neutron back in 1910, the existence of such a neutron was not verified experimentally until 1932 (Chadwick)
- ✓ While beta-minus decays were discovered by Rutherford in 1899, they were not understood theoretically until Fermi published his seminal papers that invoked neutrinos in 1934
- ✓ Neutron-capture-induced transmutation reactions were unknown possibilities until 1935 when Taylor demonstrated experimentally that boron-10 nuclei could capture thermal neutrons, which in turn caused the fission of Boron-11 nuclei into detected Helium-4 (alpha particles) and Lithium-7 ions
- ✓ Fission of Uranium was reported experimentally by Hahn & Strassman in 1938; Meitner & Frisch provided theory in 1939
- ✓ In 1946, Hoyle theorized the creation of neutrons via a direct $e + p \rightarrow n + \nu$ electroweak reaction in hot cores of dying stars
- ✓ Modern electroweak theory was articulated by Glashow, Salam, and Weinberg in the mid-1960s but not fully verified experimentally - mostly at CERN - until the end of the 1980s
- ✓ In 2006, Widom & Larsen published collective many-body theory showing how $e + p$ can occur in condensed matter

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Widom-Larsen explains arc transmutation

Processes: neutron production, captures, and decays

By using a novel integration of many-body collective effects with existing physics, the Widom-Larsen theory of LENRs explains how ultra low energy neutrons can be created under mild conditions in condensed matter devices and systems --- stars, fission reactors, or nuclear explosions are not required to trigger nucleosynthesis in tabletop apparatus

It also explains how those neutrons are then captured on target atoms to catalyze transmutations, why LENRs are ‘green’ hard radiation-free nuclear processes, and why they do not produce significant amounts of hazardous long-lived radioactive wastes

In providing detailed physics of the mechanisms for these phenomena it enables engineering of future commercial versions of revolutionary LENR-based portable nuclear power sources as well as other applications

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Births of nuclear and particle physics

Still based mostly on 1-3 particle (few-body) reactions

What is now called particle physics born in the early 1900s; experimentalists mainly use dilute, very well-characterized beams of particles to bombard a variety of targets at ever-higher energies that today reach ~7 TeV in CERN's gigantic Large Hadron Collider (LHC)

Tracing its origin to the 1890s, nuclear physics was born a little earlier than particle physics. By the mid-1930s, it was apparent to most scientists that nuclear phenomena could involve the strong interaction (fission, fusion, neutron-capture), weak interaction (beta decays and reactions that emit or absorb neutrinos), and/or the electromagnetic force (γ decay)

Importantly, the enormous body of experimental and theoretical work that has been developed around this collection of interactions and various particles since the 1890s has been based primarily on few-body (3 or fewer interacting particles) reaction kinematics. This occurred partly for computational reasons (many-body calculations are mathematically intractable, even with today's computers) and because reaction cross-sections for >3 particles are often negligible in Nature

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Nagaoka was a transmutation pioneer

Transmuted Tungsten into Gold back in 1924-25

- ✓ In a series of more than 200 experiments, Prof. Hantaro Nagaoka produced detectable Gold and Platinum during high-current electric discharges between Tungsten (W) metal electrodes immersed in hydrocarbon transformer oil laced with Mercury
- ✓ Using only limited knowledge about nuclear physics that was available at that time (neutrons and fission had not been discovered yet), Nagaoka mistakenly believed that Gold (Au) was produced as a result of high electric fields “disintegrating” Mercury (Hg) atoms into lighter Gold atoms and other constituents of atomic nuclei. This made sense in the context of his knowledge because Mercury was known to be heavier than Gold and found in same row of Periodic Table of elements
- ✓ What Nagaoka did not know back then was that during the electric discharges ultra low momentum neutrons were being created from some surface plasmon electrons (present on W electrodes) that reacted directly with Hydrogen (protons) in transformer oil. Those neutrons were captured by Tungsten atoms and transmuted them into Gold

Credit: E. M. Soriano – ETHZ Switzerland – thesis - calculated surface plasmon electron electric field intensities around cylinder on substrate; found at source URL http://alphard.ethz.ch/Moreno/moreno.htm

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Arcs thought to disintegrate atoms

Nagaoka's thinking used knowledge *circa* 1924-26

- ✓ Idea of "disintegrating atoms" to learn more about their constituents dated back to Rutherford's famous Gold foil experiment in 1909 in which a beam of alpha particles arising from decay of a Radium sample were used to bombard a thin film of metallic Gold. From the results of these experiments, Rutherford correctly deduced that atomic nuclei had to be composed of dense, tiny cores of positive charge surround by distant clouds of orbiting, negatively-charged electrons. By 1919, Rutherford was calling for development of "accelerators" that could produce more energetic MeV beams of charged or uncharged particles that could be used to bombard atomic nuclei to probe internal nuclear structure and trigger few-body reactions between nuclei and/or various elementary particles

- ✓ Nagaoka's thinking followed a rough-hewn logic: at that time there was no nuclear theory that could rigorously explain his amazing transmutation data. Chadwick's discovery of the neutron was still 6 years in the future (1932) and the idea that neutrons could be captured by atoms and transmuted to other elements would not be published until 1935 (Taylor); neutron-induced Uranium fission was first proposed by Meitner & Frisch in 1939

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Electric discharges out of favor by 1930

Forsaken by most nuclear scientists for accelerators

- By 1930, transmutations produced in various electric discharges, arcs, and exploding wires were more or less abandoned as active lines of inquiry in nuclear science, partly because underlying nonlinear physics of such discharges were not as well-understood as accelerator-driven particle beams, and especially because the energetically better-characterized particle beams provided vastly more precise control of key parameters and thus enabled better, more definitive experiments

- After electric discharge experiments became unpopular, many reports of anomalous nuclear transmutations observed in such experiments (that had accumulated in the literature since ~1900) ended-up being forgotten by the global nuclear science community --- a collection of odd data published in an earlier era that many merely chalked-up to measurement errors and contamination

Anomalous neutron production in keV-energy electric discharge experiments in a hydrogen-filled X-ray tube was observed by a PhD student working at Cornell University in 1951; Bethe and Einstein even got involved in analyzing the data (Einstein thought it might involve many-body collective effects with electrons) but the student dropped work to pursue less controversial topic

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Early ideas about transmutations in stars

Started speculating about fusion within Sun in 1933

- Idea that nuclear transmutations were occuring inside stars and creating different elements therein was broached by Millikan in 1923 *Scribner's* article published where he mused, "Has nature a way of making these transmutations in her laboratories? She is doing it under our eyes in the radioactive process … Does the process go on in both directions, heavier atoms being continually formed, as well as continually disintegrating into lighter ones? Not on earth, so far as we can see. Perhaps in God's laboratories, the stars. Some say we shall be finding out."
- In a famous theoretical paper published in 1929, Houtermans & Atkinson first proposed that thermal kinetic energies inside stars would be high enough to allow nuclei of light elements to overcome the Coulomb repulsive barrier and fuse (two-body fusion). Experimental confirmation occurred in 1933 when Oliphant used a new Cavendish particle accelerator to slam Deuterons into various targets; he produced Helium-3 and Tritium and observed liberation of excess nuclear binding energy which prompted him to speculate on fusion inside Sun

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Bethe proposed H + H fusion in 1939

Nuclear physics hijacked by weapons work in 1942

- ✓ In a landmark paper published in March 1939, "Energy production in stars", Bethe said, " … For fainter stars with lower central temperatures, the [two-body fusion] reaction H + H = D + e^+ and the reactions following it, are believed to be mainly responsible for the energy production. It is shown further that no elements heavier than He^4 can be built up in ordinary stars … Production of neutrons in stars is likewise negligible. The heavier elements found in stars must therefore have existed already when the star was formed."
- ✓ In August 1939, five months after Bethe's paper published, Szilárd wrote a fateful letter signed by Einstein to then-President Roosevelt in which they advocated development of an atomic fission bomb to counter weapons development efforts that they believed were underway in Nazi Germany. That letter then led to creation of the Manhattan Project in 1942

Since 1942, cumulative worldwide government-funded investment in nuclear science has totaled trillions of $ of R&D in few-body fission and fusion reactions for military and commercial applications and some tens of billions of $ on ever-more-powerful accelerators for pure science studies of few-body particle interactions

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Hoyle theorized $e + p$ in stars in 1946

Neutron-capture nucleosynthesis theorized in 1957

- ✓ In 1946, Hoyle theorized that $e + p \rightarrow n + \nu$ weak reaction occurs in cores of dying stars as they explode, after which a remnant neutron star would often be created
- ✓ Going far beyond Gamow and Bethe's thinking, modern concepts about nucleosynthesis in stars crystallized in a seminal 1957 paper by the two Burbidges, Fowler, and Hoyle titled, "Synthesis of the elements in stars." In this paper, they predicted the existence of the p-process and neutron-capture driven r- and s-processes to account for stellar production of elements heavier than iron (where fusion-based nucleosynthetic processes effectively end)
- ✓ Burbidge *et al*. published another follow-up paper in 1965 that, in spite of their prominent stature, was essentially ignored and forgotten by the astrophysical community. In it, they reviewed available observational evidence and concluded that --- although the mechanism was unclear --- some nucleosynthesis had to be occurring somewhere outside the dense, super-hot cores of stars. Sadly, this bold heretical idea was published way ahead of its time

By 1970, nuclear physicists were convinced that stars, fission reactors, or nuclear weapons were mandatory for nucleosynthesis to happen; idea of transmutation occurring anywhere else was thought to be impossible

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Many-body collective effects from 1940s

Russian physicists derived a key theoretical insight

While many-body collective effects were not much utilized in either nuclear or particle physics after the 1940s, thereafter they became an essential conceptual component for theory toolboxes in condensed matter and solid state physics covering diverse phenomena that includes quasiparticles, surface plasmon electrons, and superconductivity among others, as well as complex emergent phenomena beautifully described in a provocative 2005 book by R. Laughlin

- ✓ **In mid-1970s, legendary Russian physicists Landau & Lifshitz published theoretical calculation in which they showed how effective electron mass could be increased substantially by bathing electrons in nuclear-strength electric fields; it was not clear how that might be useful**
- ✓ **By mid-1970s, it became very apparent to physicists and chemists researching surface processes that that Bohr-Oppenheimer approximation (which had been used since 1927 to simplify quantum mechanics calculations that would otherwise be computationally intractable) breaks down completely on surfaces and at interfaces**

1960s and 1970s marked a resurgence of interest in exploding wires and closely related Z-pinch plasma experiments, mostly by US and Russian weapons researchers trying to trigger hot fusion reactions

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Government R&D focused on hot fusion

"Cold fusion" claimed in 1989 and discredited by 1991

Government Deuterium-tritium (D-T) fusion power R&D programs that had originally been started in the early 1950s went into massive funding during the 1970s. By 1980, tokamak and laser-driven inertial confinement fusion (ICF) concepts had emerged as front-runners for development of huge multi-billion $ machines trying to achieve energetic break-even. The ITER tokamak fusion reactor project began in 1985 and is still being built in Cadarache, France; construction began on US ICF National Ignition Facility (NIF) located at Lawrence Livermore Laboratory in 1997 and finally completed in 2009. In Oct. 2013, NIF claimed that a D-T fuel capsule had finally achieved breakeven relative to input power

- In 1989, Univ. of Utah chemists Pons & Fleischmann (P&F) erroneously claimed to have triggered Deuterium-Deuterium "cold D-D fusion" reactions in aqueous electrochemical cells that had a Palladium cathode, Platinum anode, and heavy water D_2O electrolyte laced with Lithium salts. Claims were based on measurements of excess heat and detection of Helium-4, although they acknowledged a surprising absence of deadly neutron and gamma radiation. In ensuing furor, experiments were mostly irrepeatable; thus, P&F were discredited by 1991

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Widom-Larsen explains Nagaoka's results

Theory also explains Pons & Fleischmann 1989 data

- ✓ Unfortunately for Pons & Fleischmann, their excess heat effects were irreproducible in 1989-90 because their D-D fusion hypothesis was wrong (neither one knew anything about nuclear physics); neither did they know about what is now nanotechnology and plasmonics. Thanks to W-L theory, we now know that those fields are required to reproducibly fabricate well-performing LENR heat devices
- ✓ In 2006, Widom & Larsen (W&L) published a paper that finally integrated existing many-body collective physics into modern nuclear science by applying electroweak theory to condensed matter systems under the overall umbrella of the Standard Model. It showed how the $e + p$ reaction could occur in ordinary chemical cells under very moderate macroscopic temperatures and pressures; this happens because Born-Oppenheimer breaks-down on small local length-scales on surfaces which enables creation of nuclear-strength electric fields between collectively oscillating, mutually entangled many-body collections of protons (or deuterons) and surface plasmon electrons. Effective electron masses are increased by high fields (Landau & Lifshitz) and collective production of ultra low energy neutrons via $e + p$ ensues; neutrons are captured locally causing transmutations. W&L also provided explanation for odd absence of hard radiation

Credit: E. M. Soriano – ETHZ Switzerland – thesis - calculated surface plasmon electron electric field intensities around cylinder on substrate; found at source URL http://alphard.ethz.ch/Moreno/moreno.htm

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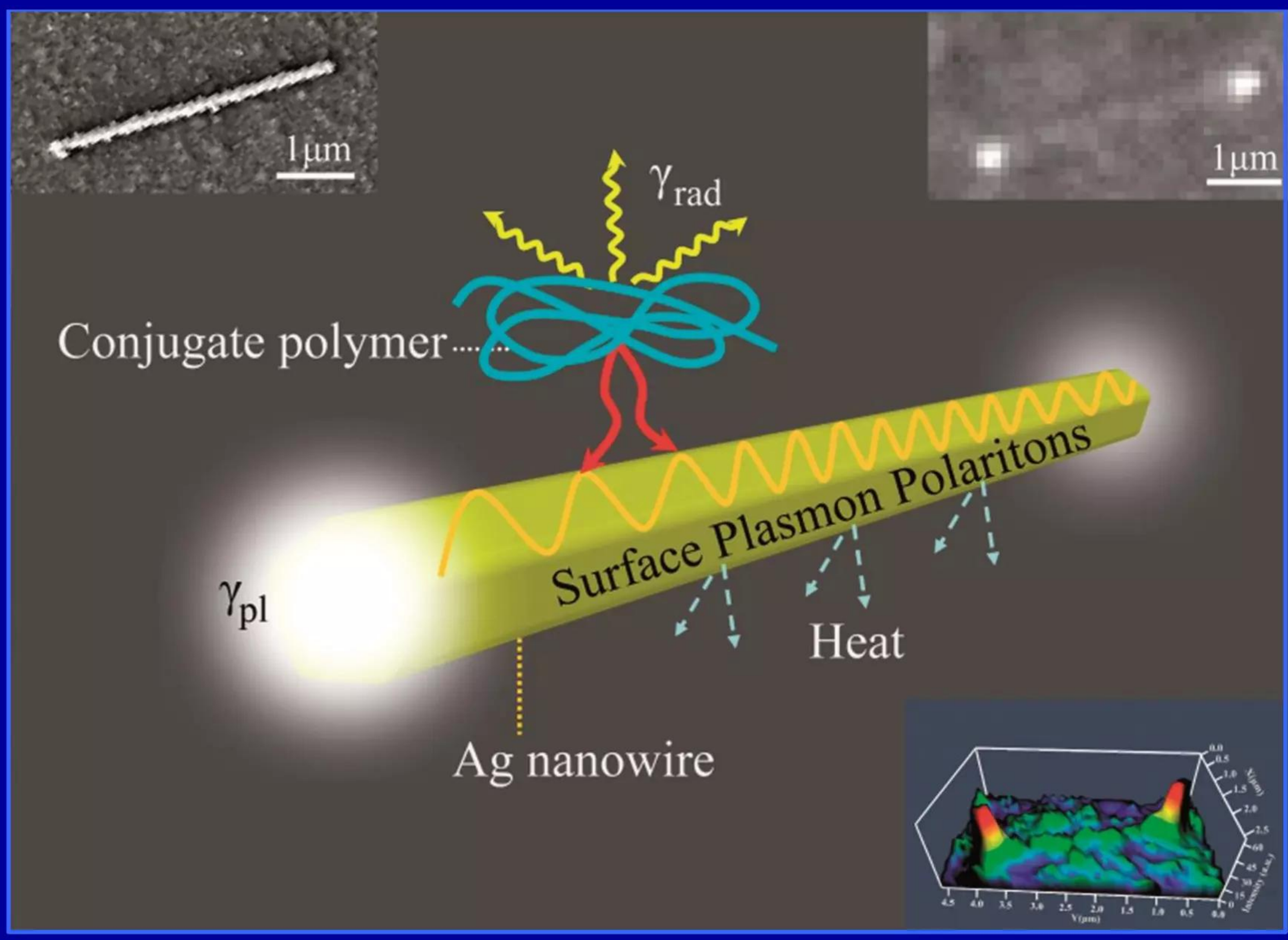
Surface plasmons play key role in LENRs

Paper illustrates some of their amazing capabilities

"Effective excitation and control of guided surface plasmon polaritons in a conjugated polymer-silver nanowire composite system"
W. Zhang *et al.*
***Journal of Materials Chemistry C* 1 pp. 1265 - 1271 (2013)**
http://pubs.rsc.org/en/Content/ArticleLanding/2013/TC/C2TC00568A#!divAbstract



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Widom-Larsen explains transmutation

Processes: neutron production, captures, and decays

Posits collective many-body creation of low-energy neutrons from electrons and protons in high nanoscale electric fields. Neutrons then locally captured by target fuels which release nuclear binding energy during captures as well as subsequent beta-decay cascades of neutron-rich isotopes that ultimately terminate in production of stable, non-radioactive elements

Synthesis of catalytic neutrons via a weak reaction:

Many-body collective effects + required added input energy

$$\text{Energy}_{\text{Electric-field}} + e^-_{sp} \rightarrow e^{-*}_{sp} + p^+ \rightarrow n_{ulm} + \nu_e$$

$$\text{Energy}_{\text{Magnetic-field}} \rightarrow e^- + p^+ \rightarrow lepton + X$$

Collective electroweak production of neutrons on nanoscale in condensed matter and large length-scale magnetic regimes

Transmutation of targets into other isotopes/elements:

Atomic number = Z Atomic weight = ~mass = A

Once created, ULM neutrons quickly capture on local atoms

$$n_{ulm} + (Z, A) \rightarrow (Z, A+1) \quad \text{[neutron capture on targets]}$$

$$(Z, A+1) \rightarrow (Z+1, A+1) + e_{\beta}^- + \nu_e \quad \text{[beta}^- \text{ decay]}$$

Typically, β^- decays of neutron-rich intermediate products

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Nagaoka's experiments now understood

LENR processes tend to follow rows in Periodic Table

Tungsten (W) → Re → Os → Ir → Pt → Gold (Au)

Periodic Table of Elements

Path of Widom-Larsen theory LENR network indicated by yellow arrow

IA											IIIA	IVA	VA	VIA	VIIA	0
1 H	IIA															2 He
3 Li	4 Be										5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	IIIB	IVB	VB	VIB	VIIB	— VII —		IB	IB	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 Y	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Br	57 La*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac*	104 Rf	105 Ha	106 106	107 107	108 108	109 109	110 110								

Platinum (Pt) and Gold (Au)

*Lanthinide Series	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	Lu Lu
*Actinide Series	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	Lr Lr

Details of one Tungsten → Gold LENR transmutation pathway shown below:

Much larger version of this particular transmutation pathway from W → Au is provided on Slide #30

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"Shows Transmuted Gold in New York"

"Dr. Nagaoka of Tokio Taking Specimens to Brussels Congress"

From: *Montreal Gazette* pp. 10 June 20, 1925

(Special to The Gazette)

New York, June 19. --- Bits of porcelain containing microscopic specks of gold which once was mercury were presented to Dr. George F. Kunz today by Dr. H. Nagaoka of Tokyo, the Japanese Einstein, who succeeded in producing artificial gold by disintegrating atoms of quicksilver in a powerful electric field.

The Japanese scientist, who sails early tomorrow morning on the Olympia for Europe to attend the International Research Congress at Brussels, brought with him a number of gold-specked fragments from the porcelain flasks in which the mercury was treated. In more than 200 experiments the change from mercury to gold has been confirmed, Dr. Nagaoka said.

Dr. Nagaoka said that he was engaged in trying to accelerate the radio-activity of uranium and to speed-up its decay. This experiment failed because the radio-active substances set up electrical effects of their own which protected them against the intense electrical action which Dr. Nagaoka sought to bring to bear against them. In this investigation, however, he found a way to concentrate an intense electrical activity in a very small field. It occurred to him that his artificial electrical storm might be severe enough to wreck atoms and change their nature. With this in view he experimented on the mercury and obtained gold.

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"Shows Transmuted Gold in New York"

"Dr. Nagaoka of Tokio Taking Specimens to Brussels Congress"

[continued]

"We have also obtained from the quicksilver a white metal which we have not been able to identify," he said. "We can prove that is it is not platinum, but can't tell what it is. It occurs in such small quantities that it defies ordinary methods of analysis. The mercury may be changed into still other substances, but we have not any further evidence on it. It appears, however, that the changes which are forced on the atom are somewhat complex."

Dr. Nagaoka said that he was skeptical about the reports that Dr. A. N. Miethe of Berlin had obtained gold from quicksilver. He said that the amount of electricity used by Dr. Miethe was not sufficient to break down the mercury atom into gold and that he suspected the gold to be a contamination.

"It might have come from the quicksilver, it might have come from the silica glass used in the experiment, or it might have come from the carbon electrode. I do not believe it was the result of any changes in atoms."

Dr. Nagaoka also expressed doubt that Rutherford had succeeded in effecting "transmutation" or disintegration of atoms by bombarding them with alpha particles. He said there was no way of confirming by chemical analysis otherwise the supposed changes in atoms resulting from the bombardment by the alpha particles given off by radium.

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Clipped images of original news story

Courtesy of Google

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Source:
http://news.google.com/newspapers?nid=1946&dat=19250620&id=2W0tAAAAIBAJ&sjid=0IsFAAAAIBAJ&pg=5346,2683180

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Nagaoka addresses IUPAP (Brussels)

The Thirteen

1. Belgium
2. Canada
3. Denmark
4. France
5. Holland
6. Japan
7. Norway
8. Poland
9. Spain
10. Switzerland
11. United Kingdom
12. United States of America
13. Union of South Africa

1922

The Ten

W. Bragg, president
M. Brillouin
O.M. Corbino
M. Knudsen
M. Leblanc
R.A. Millikan
H. Nagaoka
E. Van Aubel, vice-présidents
H. Abraham, secretary

1925

II

BRUSSELS

The Second General Assembly

: Eighteen countries send delegations.

: The General Assembly lasts one (1) hour.

: It is decided to organize an International Conference on Physics, to be hosted by the Royal Society, London.

: Younger physicists are encouraged to prepare and attend the Conference.

: Activities of the Institut international du Froid are reported: low temperature physics is involved.

: The Executive Committee is reelected; the number of Vice-Presidents is increased by four.

: Following the Assembly, scientific papers are read by Lorentz and Nagaoka on the Michelson experiment and the transmutation of mercury to gold respectively.

Source: http://www.iupap.org/file_49969.pdf

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Nagaoka's Gold sample in Kunz collection

Could potentially be analyzed with modern techniques

- ✓ "International Research Congress" mentioned in *Montreal Gazette* story still exists today as the International Union of Pure and Applied Physics (IUPAP) with administrative offices in Paris and London. In 1922, it organized its very first Executive Steering Committee consisting of 10 very distinguished scientists led by Sir William Bragg as President and including Nagaoka, Brillouin, and Millikan, who was to win a Nobel Prize in physics a year later in 1923

- ✓ As mentioned in the *Montreal Gazette* story, Nagaoka's reading of a paper about his Gold transmutation at the "International Research Congress" meeting in Brussels in 1925 is noted in a recent IUPAP document about the history of that organization

- ✓ Confirming what was stated in the *Montreal Gazette* news story, the existence of a Gold sample specimen presented to George Kunz by Nagaoka in New York is dutifully recorded in a 1925 issue of *The American Mineralogist* journal as shown below:

76 THE AMERICAN MINERALOGIST

collection and was able to show his visitors a number of species described within the last year or so, as well as magnificent specimens of well known minerals.

Dr. George F. Kunz has obtained what is reported to be the first sample of synthetic gold which has reached this country. It will form a part of the collection of elements at the American Museum of Natural History in New York. The sample of synthetic gold comes from the laboratory of Professor Hantaro Nagaoka of the Tokyo Imperial University. Dr. Kunz has also in his collection the first crystals of pure fluoride of hafnium and metallic hafnium, but does not have samples of the two new elements rhenium and masurium.

Source: http://www.minsocam.org/ammin/AM11/AM11_75.pdf

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Nagaoka's Letter to Editors of *Nature*

Foresaw possibility of commercial transmutations

"Preliminary note on the transmutation of Mercury into Gold"

H. Nagaoka, *Nature* 116 pp. 95 - 96 (1925)

Available for purchase on *Nature* archives for US$32 at:

http://www.nature.com/nature/journal/v116/n2907/abs/116095a0.html

Abstract:

"The experiment on the transmutation of mercury was begun in September 1924, with the assistance of Messrs. Y. Sugiura, T. Asada and T. Machida. The main object was to ascertain if the view which we expressed in NATURE of March 29, 1924, can be realised by applying an intense electric field to mercury atoms. Another object was to find if the radio-active changes can be accelerated by artificial means. From the outset it was clear that a field of many million volts/cm. is necessary for the purpose. From our observation on the Stark effect in arcs of different metals (*Jap. Journ. Phys*., vol. 3, pp. 45 - 73) we found that with silver globules the field in a narrow space very near the metal was nearly 2 x 10^5 volts/cm. with terminal voltage of about 140. The presence of such an intense field indicated the possibility of obtaining the desired strength of the field for transmutation, if sufficient terminal voltage be applied. Though the above ratio of magnification would be diminished with high voltage, the experiment was thought worth trying, even if we could not effect the transmutation with the apparatus at hand."

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Nagaoka's Letter to the Editors of *Nature*

From: *Nature* pp. 95 - 96 July 18, 1925

Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Preliminary Note on the Transmutation of Mercury into Gold.

THE experiment on the transmutation of mercury was begun in September 1924, with the assistance of Messrs. Y. Sugiura, T. Asada and T. Machida. The main object was to ascertain if the view which we expressed in NATURE of March 29, 1924, can be realised by applying an intense electric field to mercury atoms. Another object was to find if the radio-active changes can be accelerated by artificial means. From the outset it was clear that a field of

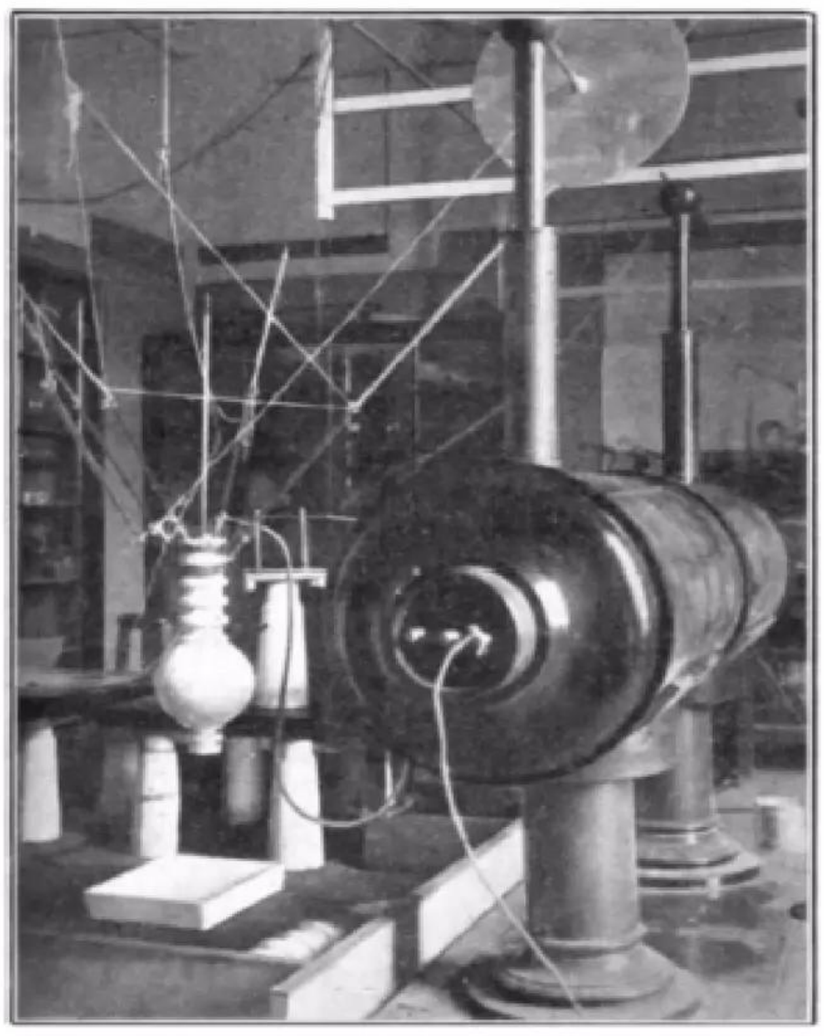

FIG. 1.—Apparatus for the electric discharge. Discharge vessel is supported on four glass insulators.

many million volts/cm. is necessary for the purpose. From our observation on the Stark effect in arcs of different metals (*Jap. Journ. Phys.*, vol. 3, pp. 45-73) we found that with silver globules the field in a narrow space very near the metal was nearly 2×10^5 volts/cm. with terminal voltage of about 140. The presence of such an intense field indicated the possibility of obtaining the desired strength of the field for transmutation, if sufficient terminal voltage be applied. Though the above ratio of magnification would be diminished with high voltage, the experiment was thought worth trying, even if we could not effect the transmutation with the apparatus at hand.

Fortunately an induction coil of 120 cm. spark length, made by Klingelfuss, was available for the purpose (Fig. 1). For keeping the terminal voltage between the electrodes sufficiently great with a short spark gap, the discharge was conducted in paraffin oil, in which a potential difference of about 15×10^4 volts/cm. can be maintained. With iron and purified mercury as electrodes, the discharge appeared at first as arcs, and the spectrum was continuous; it gave rise to abundant production of gases and carbon particles from the oil; the mercury gradually turned into fine globules, until the oil and mercury were mixed into a black pasty mass. We cannot definitely say whether the intense field observed during the experiment on the Stark effect was present during the discharge or not, but it is probable that mercury atoms have been acted upon by strong electric force during the violent bombardment, as the discharge is of an analogous nature. Continuing the discharge for about four hours, the product was examined chemically for gold by the test of Cassius'-purple; the result was decidedly positive. This experiment was performed on September 15, 1924; on succeeding days experiments were repeated, and two days after, Mr. Yasuda, an expert in gold assaying, showed us minute gold specks extracted from the black mass obtained in the experiment of the previous day. Grave doubts were, however, expressed by critics as to the purity of the mercury and also as to the possible presence of traces of gold in the chemical laboratory, due to frequent treatment of the metal.

To clear away these doubts, the mercury to be used in the experiments was first purified by ordinary chemical means, and then subjected twice or thrice to vacuum distillation, care being taken not to raise the temperature above 200°. The mercury, oil and chemical reagents used in the experiments were carefully examined by making blank tests. A room in the physical laboratory was allotted to the chemical experiments. Succeeding experiments confirmed the result, but the glass vessel was too fragile to pass the heavy condensed discharge, and it exploded during the process. Bushing insulators were tried, but the tube was too narrow, and the discharge passed into the walls. A discharge vessel of about 2 litres capacity with walls of 2 cm. thickness, provided with a long neck and a short tail for inserting the electrodes, was designed and made ready for experiment in the beginning of May. During these intervals, minor tests were made with the porcelain flask on the mode of discharge, the oil to be used for the process, the material of one of the electrodes, and easy means of detecting the presence of gold.

As we found in our investigation on the Stark effect, it is always advisable to insert condensers in the discharge circuit. We used bushing condensers of many glass plates with thin lead plates between them, the total capacity being about 0·002 microfarad. As the discharge potential is very high, the condenser plates are apt to break, and must be so large that discharge between the end plates does not take place in air.

As iron contains many impurities, we found that tungsten wire, free from thorium oxide, which we obtained through the courtesy of the Tokyo Electric Company, is the best on account of the small corrosion during the discharge.

As to the method of testing, the formation of ruby glass is delicate and in most cases accompanied by the separation of gold particles at the centre or outside boundary, which can be observed with a metallographic microscope, by using reflected light.

A special distilling flask was designed for the purpose of separating carbon, oil, and mercury from the residue in the discharge vessel, after bombarding the mercury for 10 to 15 hours. Paraffin, kerosene, and transformer oil can be used, but the last seems to be the most suitable.

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Nagaoka's Letter to the Editors of *Nature*

[continued]

The gold obtained from mercury seems to be mostly adsorbed to carbon. Ruby glass is formed by heating small pieces of glass with the carbon; in the process now used it is formed in numerous spots on the walls of the distilling flask by repeatedly heating it to about 600°. We have often separated mercury by washing the oil with benzene and ether, and after separating it from carbon by centrifugal separator, distilled it in vacuum and examined the

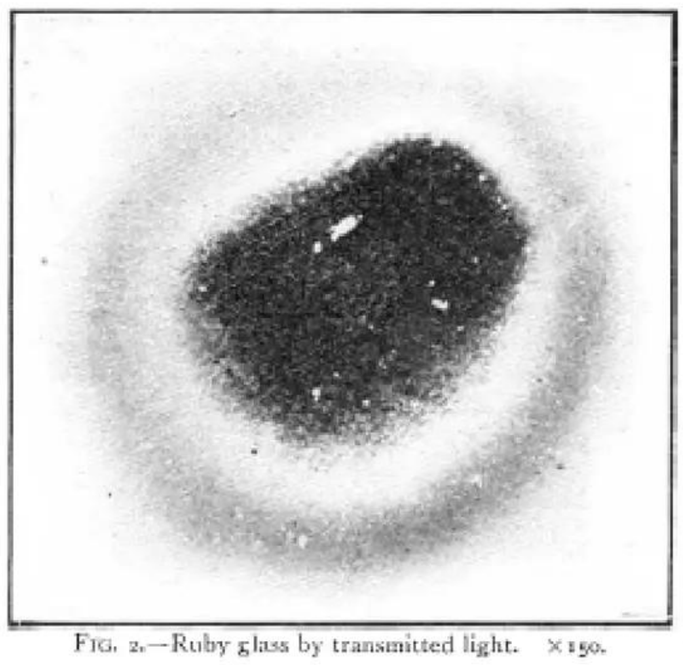

FIG. 2.—Ruby glass by transmitted light. ×150.

residue, which generally contained no gold, but a minute quantity of white metal, which may probably be another product of heavy discharge; it was, however, too small to be tested chemically.

The accompanying illustration (Fig. 2) shows a spot of ruby glass photographed with transmitted light and magnified 150 times. The central dark portion contains gold particles distributed as shown in Fig. 3 taken with reflected light and magnified

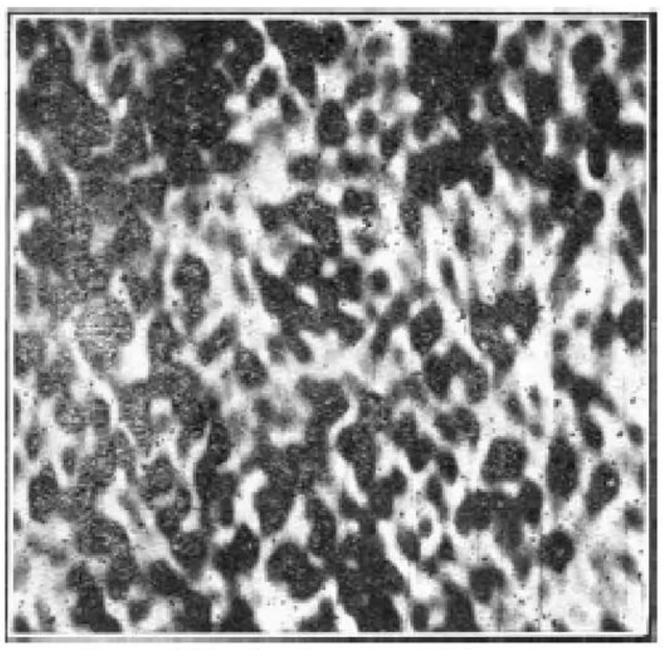

FIG. 3.—Ruby glass by reflected light. ×2500.

2500 times. It represents only a small part near the boundary of the central spot. The white ring is greenish blue, and the lightly shaded one is rosy; these colours are characteristic of gold colloids. Numerous spots of this kind are obtained in the bottom of the distilling flask during the after-treatment of a mixed mass of carbon and mercury after heavy condensed discharges. Sometimes ruby glass is apparently covered with a thin film of gold; on microscopic examination it is found to consist of fine particles of gold very densely distributed. The primary current in the induction coil in such experiments ranges from 25 to 30 amp., and the spark length in air is more than 1 m.

Probably we could produce the same effect by using lower voltage, if sufficient capacity were inserted, but the resistance of the vessel is not great enough to withstand the heavy discharge, especially when carbon and mercury are intimately mixed together. The construction of a proper discharge vessel seems at present to be a difficulty in getting an amount of gold sufficient to determine its atomic weight. Which of the isotopes of mercury is changed into gold can perhaps be inferred from the atomic weight. Spectroscopic examination will be started so soon as we can obtain sufficient material for the purpose.

The process taking place may be looked upon as due to commotion in the nucleus by intense electric force. If we assume that Coulomb's law ceases to hold within the nuclear boundary, the positively charged protons form a compact core, and the electrons within the boundary surround it. On applying an external electric field the motion of the core is opposite to that of the electrons, so that if the field be sufficiently strong, it is possible that some of the electrons may pass out of the nuclear boundary, and if the core be not very stable, some of the protons constituting it may get out. The commotion thus introduced by the external force will have some resemblance to radio-active disintegration, which must be attributed to the internal commotion of the nucleus. An experiment was made with ferro-uranium, to see if the radio-active process cannot be accelerated by applying a strong field, but owing to the ionisation it was difficult to maintain the field for a sufficient length of time. An investigation of the process of accelerating the disintegration must, therefore, be reserved for future experiments.

The experimental procedure here sketched cannot be looked upon as the only one for effecting the transmutation; probably different processes will be developed and finally lead to industrial enterprises. At present, there is no prospect of producing gold economically from mercury. Experiments with various elements may lead to different transmutations, which will be of significance to science and industry. Meagre as is the result, I wish to invite the attention of those interested in the subject so that they may repeat the experiment with more powerful means than are available in the Far East.

H. NAGAOKA.
The Institute of Physical and Chemical Research,
Komagome, Tokyo, May 26.

The Quantum Explanation of the Zeeman Triplet.

IN his letter published in NATURE of June 27, p. 978, Prof. W. M. Hicks raises some interesting points in connexion with the quantum theory of the simple Zeeman effect. As Prof. Hicks points out, the theorem of Larmor's usually taken as the basis of the theory does not define in any manner the relation between the orbits on which the rotation is superposed in the presence of the field on one hand, and the corresponding orbits before the imposition of the field on the other. The supposition that these two sets of orbits are identical is, therefore, in no way justified on the basis of Larmor's theorem alone. It can, however, be shown from purely classical considerations (see G. A. Schott, "Electromagnetic Radiation," Cambridge University Press, 1912, §302, p. 317) that, to the first order in terms involving the field, the two sets of orbits are identical. Schott's proof takes into consideration the induction

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Essence of Nagaoka's experiments

Electric arcs in oil produced Gold and Platinum

- ✓ Inside 2 cm-thick porcelain discharge vessels, Nagaoka created powerful electric arc discharges between a spark gap consisting of two metallic, Thorium-oxide-free Tungsten (W) wire electrodes (supplied by Tokyo Electric Company) immersed in a dielectric liquid "paraffin" (today referred to as "transformer oil;" general formula C_nH_{2n+2}) that was 'laced' with liquid metallic Mercury (Hg)
- ✓ Depending on experiment, arcing between the two Tungsten wire electrodes in oil was continued for 4 - 15 hours until, quoting, " … the oil and mercury were mixed into a black pasty mass." Please note that Mercury readily forms amalgams with many different metals, including Gold (Au), Platinum (Pt), and Tungsten (W)
- ✓ Small flecks of Gold were often readily visible to the naked eye and were associated with "black masses" of material observed at the end of most experiments. They also noted that, "The Gold obtained from Mercury seems to be mostly adsorbed to Carbon."
- ✓ Microscopic assays were conducted by, "heating small pieces of glass with the Carbon" to form a so-called "Ruby glass" that can be used to infer the presence of Gold colloids from visual cues that are very apparent under an ordinary visible-light microscope
- ✓ Critics complained about the possibility that the observed Gold arose from some form of "contamination." Responding to critics, Nagaoka *et al.* further purified literally everything they could think of and also made certain that new laboratory environs were squeaky clean; they still kept seeing anomalous Gold. In some experiments they had also observed, "a minute quantity of white metal." Later in 1926, Nagaoka reported to *Scientific American* - contrary to what he said in 1925 - that they had finally been able to identify the mysterious "white metal" --- it was Platinum (Pt)

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Nagaoka's experiments now understood

Did not realize Mercury's presence was a red herring

- ✓ All the ingredients for W-L LENRs to occur were present in the experiments: hydride-forming metal found therein was Tungsten (Nagaoka was unaware that Mercury was just a distracting 'red herring') which was in contact with abundant Hydrogen (protons) found in transformer oil (C_nH_{2n+2}); Born-Oppenheimer approximation broke down on Tungsten electrode surfaces; and finally, there were large non-equilibrium charged particle fluxes in the form of electrons comprising the high-current arc discharges
- ✓ Unbeknownst to Nagaoka, his high-current electric arcs probably also produced small amounts of fullerenes, carbon nanotubes, and perhaps even some graphene. ULM neutron production rates via W-L weak interaction could have been quite substantial in his high-electric-current-driven experimental system because of large energy inputs in form of powerful DC electrical currents
- ✓ Note that stable Gold can also be produced via neutron capture on stable $_{80}Hg^{196}$ which creates unstable $_{80}Hg^{197}$ that has a half-life of 2.7 days and decays via electron capture into stable $_{79}Au^{197}$. However, natural abundance (0.15%) of $_{80}Hg^{19}$ initially present in Nagaoka's 1920s experiments was so low that this alternative Au pathway cannot plausibly account for production of macroscopic naked-eye-visible quantities of Gold and Platinum flecks observed 200 times in discharge vessels post-experiment

Focusing of surface plasmon excitations on substrate surface

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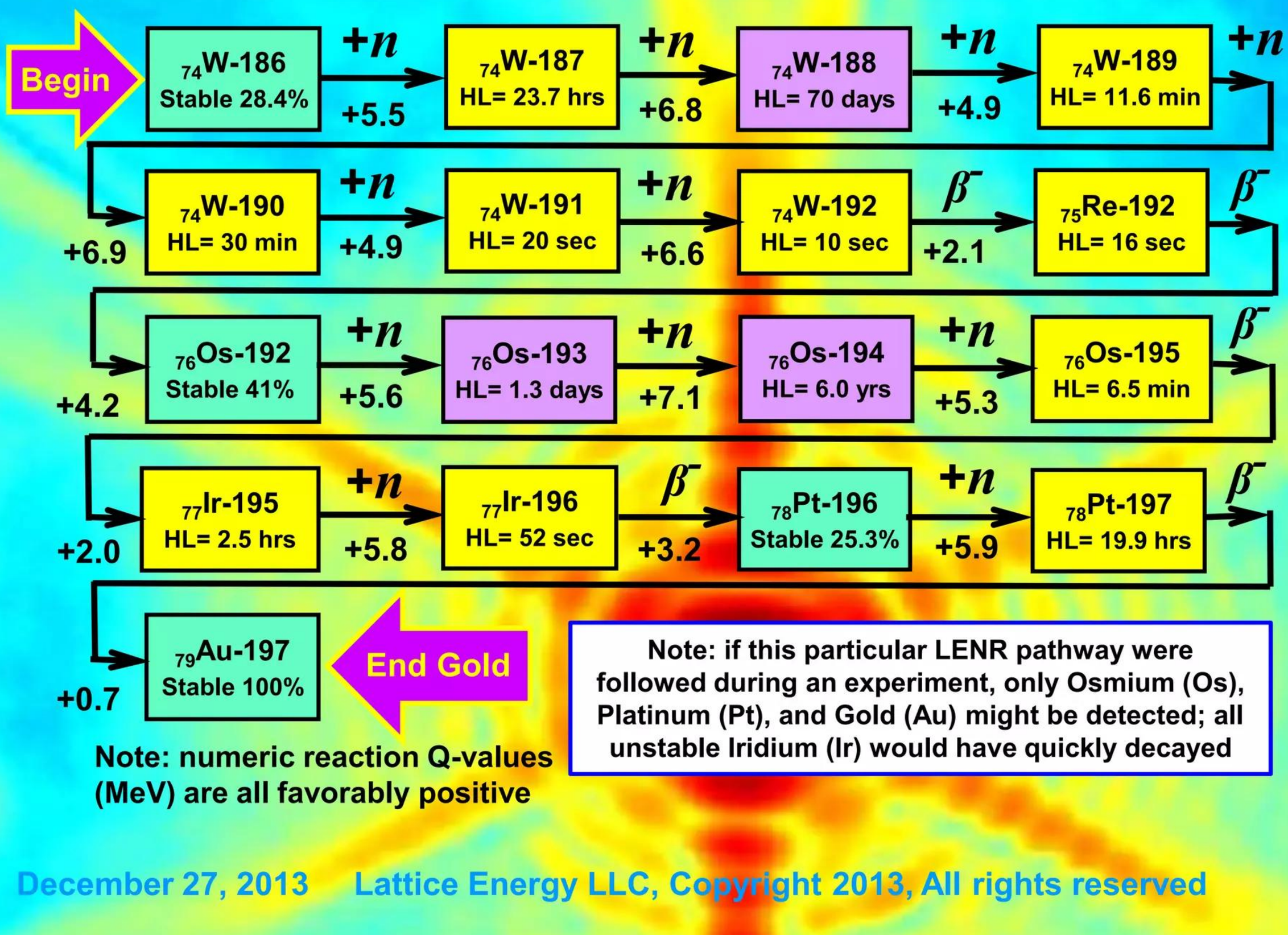
Nagaoka's experiments now understood

Tungsten target (W) → Os → Pt → Gold (Au)

- ✓ Shown below is but one example of a very energetically favorable Widom-Larsen LENR transmutation network pathway that could produce detectable amounts of the only stable Gold isotope $_{79}Au^{197}$ within roughly 4 hours (shortest arc discharge duration after which Gold was detected). Other alternative, viable LENR pathways can produce unstable Gold isotopes, e.g., $_{79}Au^{198}$ with half-life= 2.7 days and $_{79}Au^{199}$ with HL= 3.1 days (both would be around for a time at end of successful experiments).
- ✓ A very plausible $_{74}W^{180}$-target LENR network pathway is:



Note: numeric reaction Q-values (MeV) are all favorably positive

Note: if this particular LENR pathway were followed during an experiment, only Osmium (Os), Platinum (Pt), and Gold (Au) might be detected; all unstable Iridium (Ir) would have quickly decayed

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Nagaoka's results were probably correct

As far as we can tell no one questioned their veracity

- ✓ If *Montreal Gazette* accurately reported all of Nagaoka's statements, Hantaro and his RIKEN colleagues detected production of Gold metal in some 200 experiments that were conducted between September 1924 and June 1925
- ✓ Given Nagaoka's high stature internationally and long-standing reputation as a careful experimentalist, it would appear rather implausible that he and his RIKEN team would mistakenly identify some other element as Gold
- ✓ As *Gazette* reported, Nagaoka went on a world tour with talks and handed-out actual samples of produced Gold (e.g., Kunz in New York), so third parties would have had ample chances to analyze the samples. If Gold was not found to be present, someone would assuredly have questioned their claims publicly. No one did. Rutherford, a competitor of Nagaoka who had attacked Wendt & Irion with a highly critical *Nature* article back in 1922 - was uncharacteristically dead silent about RIKEN's results
- ✓ We cannot find any evidence that Nagaoka continued RIKEN's Gold transmutation experiments beyond 1926. The reason for this odd cessation is still somewhat of a mystery, as well as fact that nobody heeded Nagaoka's public plea in *Nature* for other scientists to repeat their experiments. While Hantaro recognized possibilities for commercial transmutation, he was a pure scientist and maybe abandoned arcs for better ways to explore atoms

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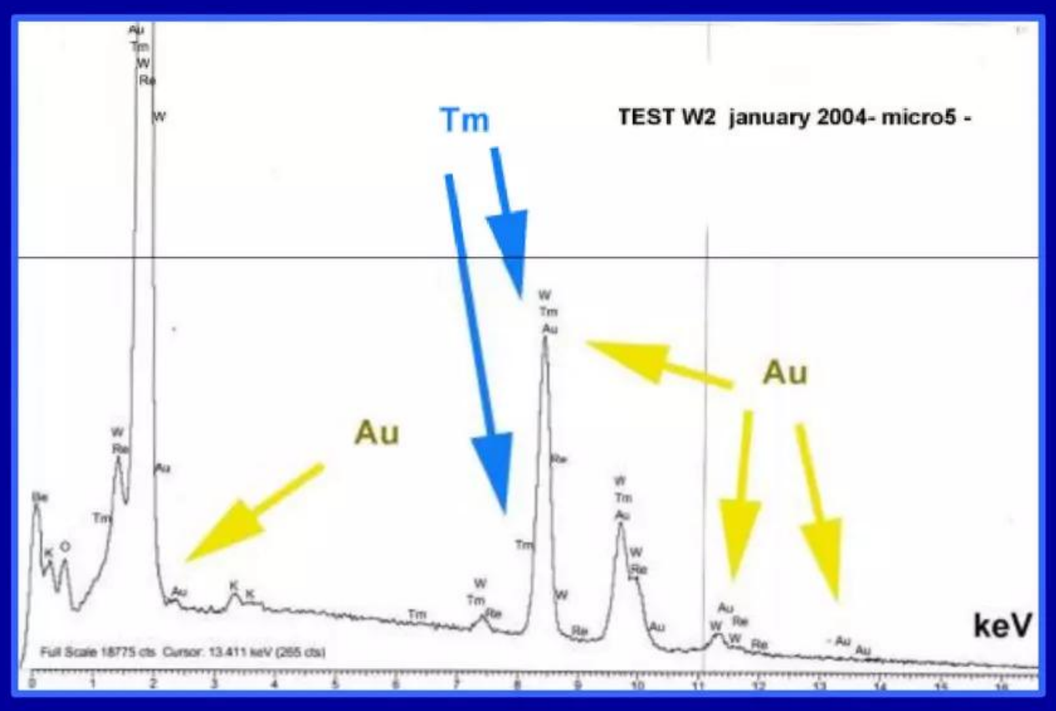
Cirillo & Iorio support Nagaoka (Italy-2004)

Transmuted Tungsten metal into Osmium and Gold



Gold (Au) and Thulium (Tm) detected post-experiment

Copy of their conference paper (2004): http://tinyurl.com/m922j6o

- ✓ **Unaware of Nagaoka's much earlier work, *ca.* 2003 - 2004 D. Cirillo and E. Iorio in Italy inadvertently designed and constructed an LENR experimental system involving electric discharges and Tungsten electrodes that, from Widom-Larsen perspective, was ~theoretically equivalent to Nagaoka's 1920s experimental set-up. They subsequently observed and reported Tungsten (W) transmutation products Rhenium (Re), Osmium (Os), and Gold (Au). These results were fully consistent with Nagaoka's and operation of a W-L $_{74}W^{180}$-target LENR network**
- ✓ **Cirillo & Iorio's modern set-up utilized an "aqueous electrolyte plasma glow-discharge cell." From an abstract broad-brush theoretical viewpoint, main differences between their new experimental system and Nagaoka's set-up of 80 years earlier was that: (1) in Cirillo & Iorio's experiments the protons needed to produce LENR neutrons came from hydrogen atoms in water (H_2O) instead of in transformer oil (C_nH_{2n+2}); and (2) no Mercury (Hg) was initially present in their system, so $_{80}Hg^{196} + n \rightarrow {}_{80}Hg^{197} \rightarrow {}_{79}Au^{197}$ electron-capture reaction can clearly be excluded as potential source of surface Gold they observed with SEM-EDX as indicated in the graphic shown above**

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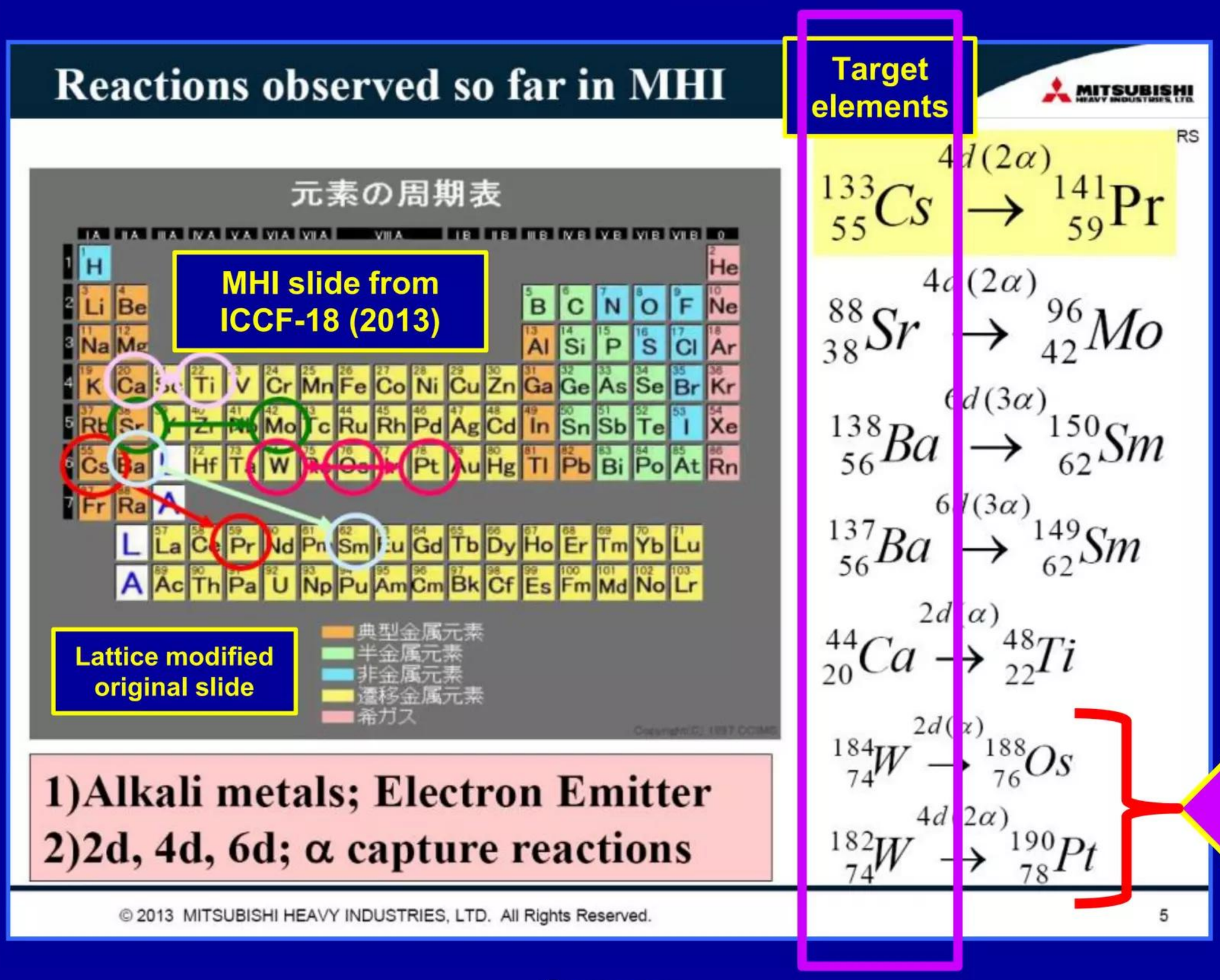
Mitsubishi supports Nagaoka (Japan-2012)

Transmuted Tungsten metal into Osmium and Platinum

At an American Nuclear Society meeting session in 2012:

Using gaseous D_2 thin-film permeation method it had pioneered in 2002, Mitsubishi Heavy Industries reported transmutation of implanted Tungsten (W) targets into Osmium (Os) and Platinum (Pt). This confirmed predicted vector of a Widom-Larsen theory transmutation network pathway and was consistent with Nagaoka's 1920s results



Source:
https://mospace.umsystem.edu/xmlui/bitstream/handle/10355/36792/RecentAdvancesDeuteriumPermeationPresentation.pdf?sequence=1

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2013 and beyond: lessons from Nagaoka

Transmutation does not require star-like conditions

- ✓ At an American Nuclear Society meeting in November 2012, Dr. Yasuhiro Iwamura of Mitsubishi revealed the Toyota Motor Company itself had recently become involved in LENR R&D, along with other large Japanese companies that he declined to name publicly. Given Japanese companies well-known excellence at long term strategic thinking, it would not be very surprising if their ongoing LENR R&D programs aimed to ultimately replace internal combustion engines

- ✓ In Oct. 2013, Toyota published a paper in the peer-reviewed *Japanese Journal of Applied Physics* which confirmed important experimental results that Mitsubishi Heavy Industries (MHI) had first published in 2002. MHI had claimed transmutation of Cesium into Praseodymium via the forced diffusion of Deuterium gas through a thin-film heterostructure containing elemental Palladium using a novel permeation method pioneered by Mitsubishi; it is capable of triggering transmutations in condensed matter systems under very modest temperatures and pressures. MHI method now authenticated

- ✓ Importantly, all of this experimental data is both predicted and fully explained by the peer-reviewed Widom-Larsen theory of low energy nuclear reactions as published in *EPJC* (2006) and *Pramana* (2010)

- ✓ While the Mitsubishi D_2 gaseous thin-film permeation method is not a suitable embodiment for commercial power generation systems based on LENRs, it has proven to be an excellent laboratory tool for demonstrating that nuclear transmutations can be triggered without the use of huge macroscopic temperatures and pressures. In other words, aging stars, supernovae, nuclear fission reactors, and thermonuclear explosions are not required for initiation; star-like transmutations of elements can be triggered in small-scale 'tabletop' systems that do not have or require any shielding for MeV radiation

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2013 and beyond: lessons from Nagaoka

Nagaoka's discharge experiments should be repeated

> "The energy produced by breaking down the atom is a very poor kind of thing. Anyone who expects a source of power from the transformations of these atoms is talking moonshine."
>
> Ernest Rutherford, 1933

- ✓ **Three sets of experiments separated in time by as much as 88 years effectively confirm neutron-catalyzed transmutation vector from Tungsten to Gold that is predicted by the Widom-Larsen theory of LENRs;** namely, Nagaoka *et al.* (Japan, 1925); Cirillo *et al.* (Italy, *ca.* 2004); and report made at American Nuclear Society Winter Meeting session on LENRs in San Diego, CA, by Yasuhiro Iwamura *et al.* (Mitsubishi Heavy Industries, Japan, 2012)
- ✓ **In 2013, Toyota effectively confirmed MHI transmutation method**
- ✓ **Today, metallic gold found in economically valuable ores is often in form of microscopic particles of metal (invisible to the naked eye) that are embedded in rock matrix. By contrast, Prof. Nagaoka *et al*. reported seeing significant numbers of macroscopic flecks of Gold in "black masses" of reacted material. If such Au and Pt flecks had instead been found in rock samples collected in the field, it would suggest the possible presence of a rich ore body**
- ✓ **Somebody should try to locate and analyze any surviving Gold specimens handed-out by Nagaoka in 1925; e.g., sample in Kunz Collection at American Museum of Natural History in New York**
- ✓ **Someone should try to repeat Nagaoka's electric arc experiments**
- ✓ **If repetition of 1920s experiments produced encouraging results, commercial transmutation of Gold might not be very far in future**

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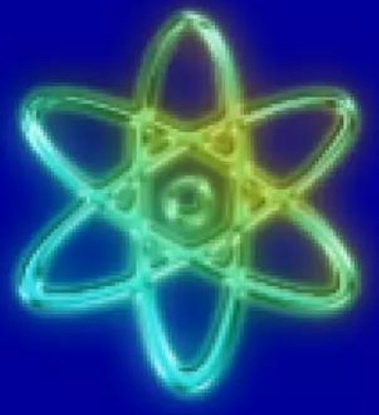
2013 and beyond: lessons from Nagaoka

Widom-Larsen theory enables engineering of devices

Fission and fusion

Evolution



Green LENRs

"I have learned to use the word 'impossible' with the greatest caution."

Wernher von Braun

Lewis Larsen

President and CEO
Lattice Energy LLC

December 27, 2013

Contact: 1-312-861-0115
lewisglarsen@gmail.com

http://www.slideshare.net/lewisglarsen/presentations

All source URL hyperlinks in this document are live and tested

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Additional References

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L. Larsen, Lattice Energy LLC, May 19, 2012 [66 slides]

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"Neutron-catalyzed LENR transmutations produce Gold from Tungsten; Mitsubishi Heavy Industries presents new data at Winter ANS meeting - Comparable results: three sets of different experiments separated by as much as 88 years"
L. Larsen, Lattice Energy LLC, December 7, 2012 [29 slides]

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-lenr-transmutation-networks-can-produce-golddec-7-2012

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L. Larsen, Lattice Energy LLC, Oct. 31, 2013 [100 slides]

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L. Larsen, Lattice Energy LLC, July 4, 2013 [60 slides]

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L. Larsen, Lattice Energy LLC, Dec. 13, 2013 [75 slides]

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"Index to key concepts and documents" v. #15
L. Larsen, Lattice Energy LLC, May 28, 2013 [108 slides]
Updated and revised through December 4, 2013

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-index-to-documents-re-widomlarsen-theory-of-lenrsmay-28-2013

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All source URL hyperlinks to references are live and tested

"Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces"

A. Widom and L. Larsen [first peer-reviewed paper published on Widom-Larsen theory; preprint on arXiv May 2005]

***European Physical Journal C - Particles and Fields (EPJC)* 46 pp. 107 - 112 (2006)**

Live hyperlink: http://www.slideshare.net/lewisglarsen/widom-and-larsen-ulm-neutron-catalyzed-lenrs-on-metallic-hydride-surfacesepjc-march-2006

[as-published author's copy of paper]

Abstract: "Ultra low momentum neutron catalyzed nuclear reactions in metallic hydride system surfaces are discussed. Weak interaction catalysis initially occurs when neutrons (along with neutrinos) are produced from the protons that capture 'heavy' electrons. Surface electron masses are shifted upwards by localized condensed matter electromagnetic fields. Condensed matter quantum electrodynamic processes may also shift the densities of final states, allowing an appreciable production of extremely low momentum neutrons, which are thereby efficiently absorbed by nearby nuclei. No Coulomb barriers exist for the weak interaction neutron production or other resulting catalytic processes."

"A primer for electro-weak induced low energy nuclear reactions"

Y. Srivastava, A. Widom, and L. Larsen [review paper; covers all theoretical aspects of Widom-Larsen theory to date]

***Pramana - Journal of Physics* 75 pp. 617 - 637 (2010)**

Live hyperlink: http://www.ias.ac.in/pramana/v75/p617/fulltext.pdf

Abstract: "Under special circumstances, electromagnetic and weak interactions can induce low-energy nuclear reactions to occur with observable rates for a variety of processes. A common element in all these applications is that the electromagnetic energy stored in many relatively slow-moving electrons can (under appropriate circumstances) be collectively transferred into fewer, much faster electrons with energies sufficient for the latter to combine with protons (or deuterons, if present) to produce neutrons via weak interactions. The produced neutrons can then initiate low-energy nuclear reactions through further nuclear transmutations. The aim of this paper is to extend and enlarge upon various examples analyzed previously, present order of magnitude estimates for each and to illuminate a common unifying theme amongst all of them."

**"Nothing is too wonderful to be true,
if it be consistent with the laws of nature;
and in such things as these experiments
is the best test of such consistency."**

Michael Faraday

**Laboratory journal entry #10,040
March 19, 1849**

Photo credit: Ken Ward - crystalline Gold Wires on Quartz matrix from Little Jonny (Ibex) Mine, Leadville, Colorado, USA

