

LENR and NASA

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“ Energy is really the key to Space
Travel”

Outline

- What
- Status
- Why
- Plans

LENR [Low Energy Nuclear Reactions] Precis

- Originally dubbed “Cold Fusion”, an experimental discovery with replication issues and no acceptable theory
- Now, over 2 decades of world-wide data collection/experiments indicate is “real”
- Now, a Weak Interaction Theories [Widom/Larsen, etc.]
- Not “Hot Fusion”, electroweak interactions explicable via the “Standard Model” of Quantum Theory on Surfaces
- Theory being used to increase heat “quality” and practicality, Minimal radiation safety issues

A Conjectured LENR PROCESS

- Load H₂ onto a metal surface, Plasmons initiate collective effects
- Add energy, produce high voltage gradients at cracks/ asperities
- Gradients excite electrons, via collective effects [QED] to combine with protons to form an ultra low momentum neutron, never leaves the surface
- Neutron readily absorbed, neutron rich isotope undergoes beta decay , emits heat

“Preliminaries”

- IS IT REAL? - Over 2 decades with over 100 experiments worldwide indicate LENR is real, much greater than Chemical, Transmutations, Minimal radiation
- WHAT IS IT? – Theories indicate is weak interactions/ beta decay, NOT “Fusion”
- IS IT USEFUL? – There are several experimental claims of “useful” quantities of heat, thus far in the watts-to-KWs range

Current LENR SOA

- Most of the 2 decades of experiments, lacking theoretical guidance, produced low levels of energy. Most used the P-F D/Pd electrochemical cells
- Zawodny et al at LaRC utilized theory to attempt to increase energy output, under experimental investigation
- From the world wide experiments a huge number of “knobs”/ approaches appear to “work”, issue is how good can it be? Requires experiments guided by theory and major “creative” efforts/ inputs along with CAREFUL Experiments,

Summary of Evidence in Expts. For Weak Interaction/ Nuclear Effects

- He4 produced
- Transmutations, which/what dependant upon experiment details
- Energy produced at levels beyond chemical
- Little worrisome radiation, no dead graduate students, No way to overcome Coulomb Barrier via strong force physics

Summary of Evidence for Weak Force

- Metal hydrides of both H & D
- High H loading required
- Not just ^4He being produced
- Range of elemental transmutations
- Energy input needed
- Forcing at resonant hydride frequencies is effective
- Only Sporadic detection of neutron or gamma radiation

WLT Predictions

- Reaction rate is related to the SPP amplitudes at the proton resonant frequency
- Reactions are sporadic on smooth or randomly patterned devices driven by broadband SPPs
- Reaction rate should increase when driven at the proper frequency (e.g., multi-wavelength lasers)
- Reaction rate should increase for patterned / resonant devices (focus of ongoing LaRC experiments)

Benefits of LENR Technology

- LENR may solve Global Climate and Energy.....
- A 10KW device would solve oil issues, power transportation, provide distributed generation for homes, some industrial applications, desalinate water
- Theory indicates scales from PDAs to GW Power plants, could possibly replace petroleum, natural gas and coal, as well as Fission Nuclear. Possibly less expensive than “conventional “Renewables”

LENR Technology could also possibly clean up radioactive waste via transmutation as well as produce elements in short supply [e.g. rare earths].

Overall – Vast impacts upon Climate, Econometrics, National Security and Quality of Life

NASA Interest[s] in LENR

- Direct and potentially massively/ truly “game-changing” Applications across the board to NASA Mission Areas:
 - Science
 - Exploration
 - Aeronautics

NASA Science LENR Applications

- Superb light weight power/ energy sources for space probes/ instruments and hoppers/ rovers, far less expensive than solar and better than radiologics for beyond Mars where solar does not “work”
- Reduced LEO and in space propulsion weights/ costs
- Solves EDL for large payloads to Mars via ingestion, heating and retro injection of atmospheric CO₂

NASA Exploration LENR Applications

- Preliminary systems studies indicate LEO access rockets with Nuc Thermal Isp [~ 800 Seconds] sans the Nuc radiation protection weights/ safety issues
- On Planet Nuc power/ Energy without usual Nuc Radiation protection/ safety issues
- Potentially obviates order of 80% of the 1000 metric ton LEO up-mass for Humans Mars which is in-space fuel, Propulsive mass from far outer region atmosphere or regolith
- Source for energy beaming, energy to terraform Mars, Enables Active Space Radiation Protection

This technology produces transmutations, i.e. could be used for ISRU to produce/ provide requisite materials/ elements not otherwise available

NASA Aeronautical LENR Applications

- Overall, enables what we have never had - “Energy Rich” design space[s]
- Fuel fraction could become negligible, huge impacts upon vehicle gross weights, especially for SST’s which are some 55% fuel fraction
- Use to replace combustors in GTE’s or via Sterling or T-E’s to generate electricity for electric propulsors

Aeronautical Applications Continued

- Huge range increases
- Enables VTOL and PAVE both economical and QUIET
- Enables design for ultra low noise via degrading propulsor performance
- Mitigates sonic boom via focused energy projected far forward to reduce shock strength, “lengthen” vehicle virtually

Aeronautical Applications Continued

- Makes SST's affordable via huge gross weight reductions, reduces sonic boom, enables emission compliance
- "Solves" emissions except for NOx, which can be mitigated via "design" or obviated if go electric
- Enables huge loiter capability for "sensor craft" [military, climate/ science, law enforcement, HALE Sat substitutes, etc.

Aeronautical Applications Continued

- Reduces both acquisition and operational costs
- Enables envelope-less flight via active flow control, “Bird Like Flight”, ALL-WEATHER
- Provides huge margins to enable superb safety [Armored engine surrounds, triply redundant Faraday caged Electronics, Etc..]

Aeronautical Applications Continued

- Allows direct control of wake vortices to obviate wake vortex hazard
- Super STOL performance via circulation/ flow control to increase runway productivity by a factor of 3
- Overall, For Aero – far lower gross weights, higher speeds, lower noise, greater range, emissions solved, envelope-less/all weather superb ride quality flight, lower costs, greater safety

Aeronautical Applications Continued

- Possibly obviates THE issue with hypervelocity air-breathing, the decreasing value-added from burning H₂ fuel as a function of increasing vehicle kinetic energy

In Short, LENR , depending upon the TBD performance, appears to be capable of Revolutionizing Aerospace across the board. No other single technology even comes close to the potential impacts of LENR upon Agency Missions.

Comments on LENR Going Forward

- Test/ determine the performance of the extant devices
- Experimentally validate the weak interaction theories
- Utilize theory to design/ create and experimentally optimize performance, including surface morphology considerations/ opportunities and bootstrapping
- Summarize the myriad approaches throughout the entire system/ sequence that appear to work [e.g. the several methods of adding energy].

Comments Continued.....

- The 2 decades of experiments and the weak interaction theories have removed the existential risk, what is remaining is to ENGINEER for improved performance. Also obviously all the safety issues, labs have blown up studying this arena
- SO – We need to Invent/ create optimized/ improved, SAFE LENR “Devices”

WHY has it taken some 22 years?

- Is apparently/ possibly a non-obvious engineered PROCESS exploiting The Weak Force
- Initial claims of “cold Fusion” Seriously “Poisoned the well”, became the Energetics UFO, 3rd Rail
- Required nearly 2 decades of experiments AND the Weak Interaction Theory to convince some folks [e.g. LaRC] to study this

WHY - continued

- Claims of cold fusion, lack of Physics understanding and low energy production levels held this up

WHY 22 Years - Summary

- Initially little understanding, replication issues, low heat production, cold fusion red herring – few were interested
- 22 years of expts. provide an existence proof
- Weak INTERACTION theories provides an “understanding”
- Now an EXTREME requirement for inexpensive clean energy and a NASA “affordability” problem

Utilization Approaches

- LENR produces Heat, Depending upon design potentially from the theory a great deal of heat
- Can utilize the Heat directly as in open propulsion systems etc. or via such as Sterling cycles, Thermoelectrics, Pyroelectrics, T-PV etc. convert the heat into electricity
- High power density may be possible with minimal radiation issues/ problems/ weights and inexpensive fuels/ systems.

We went directly from Chemical to strong force Nuc and in the process bought huge energetics improvements and radiation protection/ safety issues that precluded many fission nuc application[s], We leapt over the weak interaction energetics landscape except for radiologics. We are back-tracking...

This appears to be one of those massively game-changing Techs that appear once a generation or less. We will spend the next 20 years understanding and ideating/optimizing Weak Force Engineering, a blank page [except for some existing Edisonian devices] to be written on.

Physics Outlook/Issues

- Quantum and Relativity do not “Merge”
- They do not explain “Dark Energy”[~ 73% of the Universe]
- They do not explain “Dark Matter”[23% of the Universe]
- They do not provide an “understanding” of “Non-Locality”
- Where did the Anti-Matter Go?.....
- 100 plus orders of magnitude difference[s] wrt ZPE between Quantum theory and the operable Cosmological Constant
- Many other “Unsolved Problems”/Anomalies.....

Extant “Explanation” Approaches

[Samples, Additional Degrees of Freedom,
Experimental Verification TBD..]

- Time Reversals/Retrocausation”
- Extra [Spatial] Dimensions
 - Many Worlds/Multiverses
 - String/M/Brane Theories [to 11 Dim.]
 - 5 Dim. Larger Universe/ “The Bulk”
- “Larger Constructs”
 - Bohm Quantum Potential
 - Holographic Universe
 - Puthoff ZPAether, Winterberg Planck Aether
- Non-Linear Quantum Theory

Quantum Sitrep.....

- MAGNIFICANT Theory accurate in some cases to 16 to 26 decimal places
- Applications largely based upon “shut up and compute” and FAPP [For all practical purposes]
- No quantum gravity [yet..]
- Quantum Ontology a cottage industry “work in progress”
- “Meaning” of entanglement still “elusive”

What is Sought are “Explanations” for
Dark Matter/Energy and Non-Locality
Etc. which satisfy Occam’s Razor &
Experimentally verified.

Once Found/Determined the
Ensuing/Enabled Technologies should
be Seriously Revolutionary, including
wrt Energy, Stay Tuned.....[ZPE,
Gravity Control, Warps/ Worms,
Teleportation?]

**If God had wanted
people to go to Space,
She would have given
them more Money**

***Mark Albert
Scientific American***