Expectations of LENR Theories

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12th International Workshop on Anomalies in Hydrogen Loaded Metals

5-9 June 2017

Hotel Langhe e Monferrato, Via Contessa di Castiglione, 14055 Costigliole d'Asti (AT), Italy

Motivations

There are dozens of theories about what causes LENR.

Most are incompatible with other LENR theories.
Theories are ultimately in competition with each other.

Assessing the characteristics and status of each theory
is a major first step toward down selecting theories.

Milestones in Evaluation of LENR Theories

1994 Review paper by Chechin *et al*.
2008 Matrix of theories presented at ICCF-14.
This Conference

This paper is a related, but different, approach to the dozens of LENR theories. It is not a review or evaluation of LENR theories. Rather, it offers questions, the answers to which would enable people interested in LENR to understand the characteristics and status of various theories.

Review Paper Published in 1994

Critical Review of Theoretical Models for Anomalous Effects (Cold Fusion) in Deuterated Metals

V.A. Chechin[1], V.A.Tsarev[1], M. Rabinowitz[2], and Y.E. Kim[3]

Abstract

We briefly summarize the reported anomalous effects in deuterated metals at ambient temperature, commonly known as "Cold Fusion" (CF), with an emphasis on important experiments as well as the theoretical basis for the opposition to interpreting them as cold fusion. Then we critically examine more than 25 theoretical models for CF, including unusual nuclear and exotic chemical hypotheses. We conclude that they do not explain the data.

V. A. Chechin *et al.*
"Critical review of theoretical models for anomalous effects in deuterated metals"
www.lenr-lanr.org/acrobat/ChechinVAcriticalre.pdf

Review Paper Published in 1994

“We conclude that in spite of considerable efforts, no theoretical formulation of CF has succeeded in quantitatively or even qualitatively describing the reported experimental results .

Those models claiming to have solved this enigma appear far from having accomplished this goal…....

We have been limited largely in investigating the consistency of the theories with the fundamental laws of nature and their internal self-consistency. A number of the theories do not even meet these basic criteria.

It is imperative that a theory be testable, if it is to be considered a physical theory.”

Questions about LENR Theories in 2008 from ICCF-14

1. What is the form of the reaction(s) considered? (“*Which LENR?*”)

2. Does the paper deal with the Coulomb barrier? (“*Coulomb barrier*”)

3. Does the paper deal with the presence or absence of energetic particles? (“*Hi-energy particles*”)

4. What is the conceptual foundation of the theory? (“*Concept*”)

5. Has the concept been reduced to equations? (“*Equations?*”)

6. Have numerical results been provided? (“*Numerical Results?*”)

7. Have the results been applied? (“*Use of Results?*”)

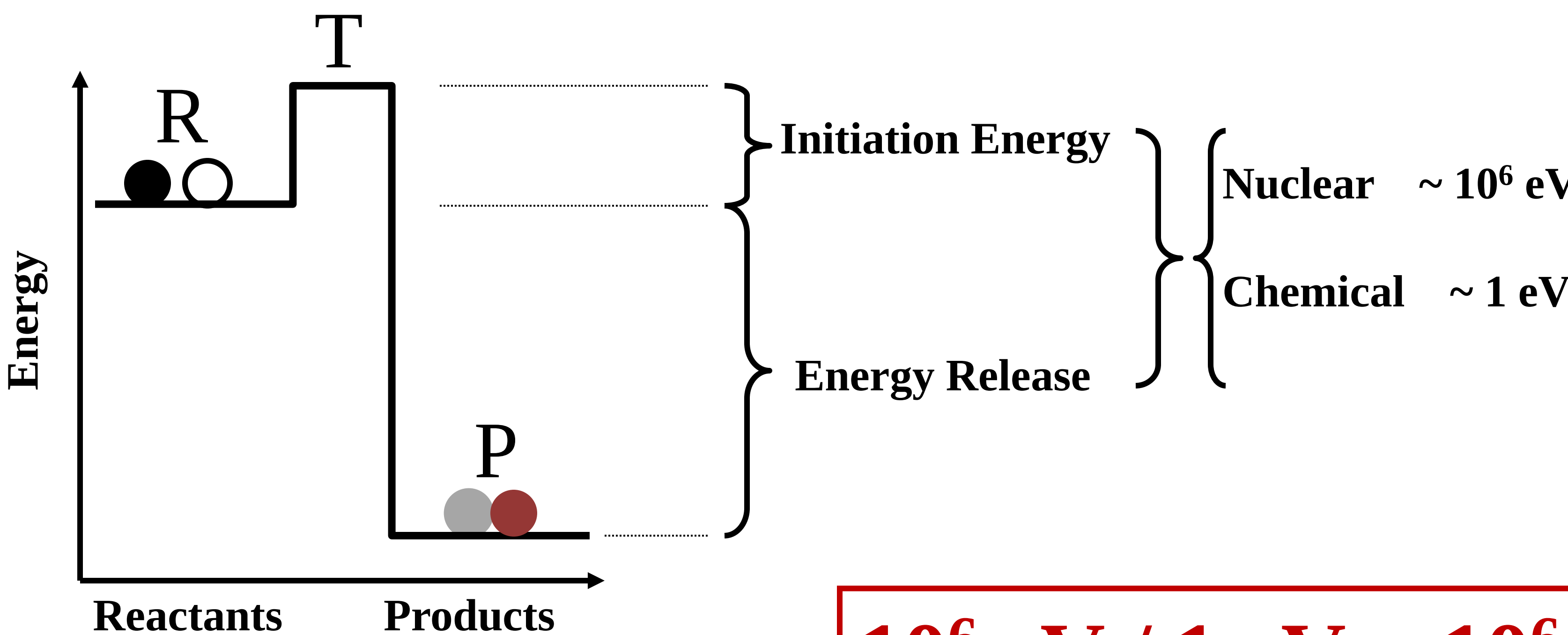
Matrix of Theories Presented at ICCF-14

by Rodney Johnson

	Authors	Which LENR?	Coulomb Barrier	High-Energy Particles	Concept	Equations?	Numerical Results?	Use of Results?	Comments
1	Adamenko, Vysotskii	Transmutation	N/A	N/A	Magnetic monopoles	Yes	Approx. bounds	No	
2	Alexandrov	$e + P \rightarrow N + \nu$	Neutrons	No	Band theory, effective mass	Yes	Yes	Applied to semicond.	
3	Bass, Swartz	D fusion	No	No	Control theory	Computer simul.	Yes	Future work	
4	Breed	$4D \rightarrow \alpha + \ldots$	Yes	Yes	Band theory, effective mass, resonance	Yes	No	N/A	
5	S. Chubb	$D{+}D \rightarrow {}^4He{+}heat$	Yes	Yes	Nonlocal quantum effects, resonance	Yes	Yes	No	"Real barrier is conceptual"
6	T. Chubb	Various	Yes	Yes	"Ion band states"	No	No	N/A	
7	Cook	Transmutation	No	N/A	Lattice model of nuclei	Yes	Yes	Compare with exp't	
8	Dufour et al.	Pd+D, D+D	Yes	Indirectly	New force	No	No	N/A	
9	Fou	D+D fusion	Yes	No	Neutron exchange, electrostatic fields	No	No	N/A	
10	Frisone	D plasma oscillations	Yes	N/A	Gamow and Preparata theory	Yes	Yes	No	
11	Godes	$e + P \rightarrow N + \nu$	Neutrons	No	Various	No	No	N/A	
12	Hagelstein, Chaudhary	$D{+}D \rightarrow {}^4He{+}24\ MeV$	Yes	Yes	Coupling 2-level systems to phonons	Yes	Qualitative	N/A	
13	Hagelstein, Melich, Johnson	Various	Yes	Yes	Various	N/A	N/A	N/A	Survey of experiments
14	Hagelstein et al.	Various	No	No	Existing theory	Yes	No	N/A	General framework
15	Kim	$D{+}D \rightarrow {}^4He{+}heat$	Yes	Yes	Bose-Einstein condensate	Yes	Yes	Yes	
16	Kozima	Not stated	No	No	Cellular automata, recursion equations	No	No	N/A	Complexity theory
17	Kozima, Date	Transmutation	Neutrons	No	"Neutron drops"	No	No	N/A	
18	Li et al.	$D + P + e \rightarrow {}^3He + e + \nu + \bar{\nu}$	Neutrons	Indirectly	Resonance, tunneling	Yes	Yes	No	
19	Sinha, Meulenberg	D fusion	Yes	No	Screening via local e^- pairs	Yes	Yes	No	
20	Swartz	D fusion	No	No	Relations between operating parameters	Yes	Approx.	Yes	
21	Swartz, Forsley	D fusion	No	No	Relations involving operating parameters	Computer calculations	Qualitative	Yes	
22	Takahashi	$4D \rightarrow {}^8Be^* \rightarrow 2\alpha$	Yes	No	"Tetrahedrally symmetric clusters"	Yes	Yes	No	

Page 476 of the Proceedings of the 14th International Conference on Condensed Matter Nuclear Science (ICCF-14).
Edited by David J. Nagel and Michael E. Melich
https://www.iscmns.org/iccf14/ProcICCF14b.pdf

Chemical and Nuclear Reactions



$$\boxed{10^6 \text{ eV} / 1 \text{ eV} = 10^6}$$

1. How is your theory connected to LENR?

Some concepts presented at LENR conferences have no stated or evident connection to LENR.

It is reasonable to ask if a given idea seeks to explain everything about LENR, or just some aspect of what was measured.

Some work on nuclear structures and on nuclear reactions, which is presented in our conferences, does not get as far as making a connection to LENR.

2. What is the key idea or concept of your theory?

All theoretical developments must start with some idea or concept about what is happening to make it possible to induce nuclear reactions with chemical energies.

3. What is (are) the foundation(s) of your concept?

This question asks what is the basis in physics, chemistry, biology, electromagnetics and other sciences of the mechanism at the core of a theoretical idea.

What advanced knowledge of what sciences is needed to proceed?

What is assumed at the outset of a specific theoretical development?

4. Does your mechanism involve only one step or more than one step?

There are three types of possible reactions: Chemical, Exotic and Nuclear

Chemical reactions include electrochemical and solid-state mechanisms, which are needed to create Nuclear Active Environments in Nuclear Active Regions

Exotic reactions include the formation of compact objects or other entities, which are neither ordinary chemical nor nuclear reactions

Nuclear reactions include any mechanism which produces changes in the nuclei that are involved in the reactions, whether fusion, fission, transmutations or ???

The number and type of reactions during LENR experiments is rarely discussed.

The Number and Sequence of Multiple Reactions Can Vary Greatly

Almost all reactions have this sequence: R $\longrightarrow$ T $\longrightarrow$ P

If production of a Nuclear Active Environment is always the initial step, then all LENR experiments involve two steps. That initial "reaction" is probably chemical in nature.

Hence, there are two likely sequences needed for production of LENR:

Chemical $\longrightarrow$ Nuclear

Chemical $\longrightarrow$ Exotic $\longrightarrow$ Nuclear

However, this does not exhaust possibilities. Some LENR theories do not involve nuclear reactions at all.

5. Are the equations that embody your concept written out?

If this is not done, the "theory" is nothing more than a concept, which is untestable, and has no value for either explaining past experiments or designing new experiments.

The challenge is to have all needed the equations and no more.

6. If the equations are available, have they been evaluated, that is, reduced to numbers?

There is no way to know from equations alone if the idea(s) behind them is (are) correct, or if the equations are complete and correct.

Science is all about numbers, and stopping at the equations stage is like preparing for and starting a race only to quit part way through it.

Numerical evaluations require considerations of algorithms, codes and machines because each of these can influence the numerical results.

7. What time histories and reaction rates are (quantitatively) predicted?

Theoretical rates are testable, and are the basis of applications.

For mechanisms involving more than one step, which step is rate limiting?

8. How does your mechanism involve relate to experimental observations?

It is possible to initiate nuclear reactions, each of which gives energies of about one million electron volts, by using chemical energies on the order of one electron volt.

High temperatures are not needed to produce LENR, but reaction rates increase with temperature in electrochemical experiments.

There are four approaches to LENR experiments, namely the use of liquids, gases, plasmas and beams to load hydrogen isotopes into certain solids, notably Palladium.

Materials are critical to production of LENR, including high loading, surface orientation and morphology and the presence of impurities.

Four types of measurements, heat that cannot be explained by chemistry, nuclear reaction (transmutation) products, low intensities of energetic particles and some low energy phenomena, all point to the occurrence of nuclear reactions.

Values of generated energy (in electron volts per atom of the metal catalyst) in excess of 20,000 have been observed in LENR experiments.

Power gains in excess of 25 have been observed in a few experiments.
Power densities exceeding those within nuclear fission fuel rods by 100 times have been measured.

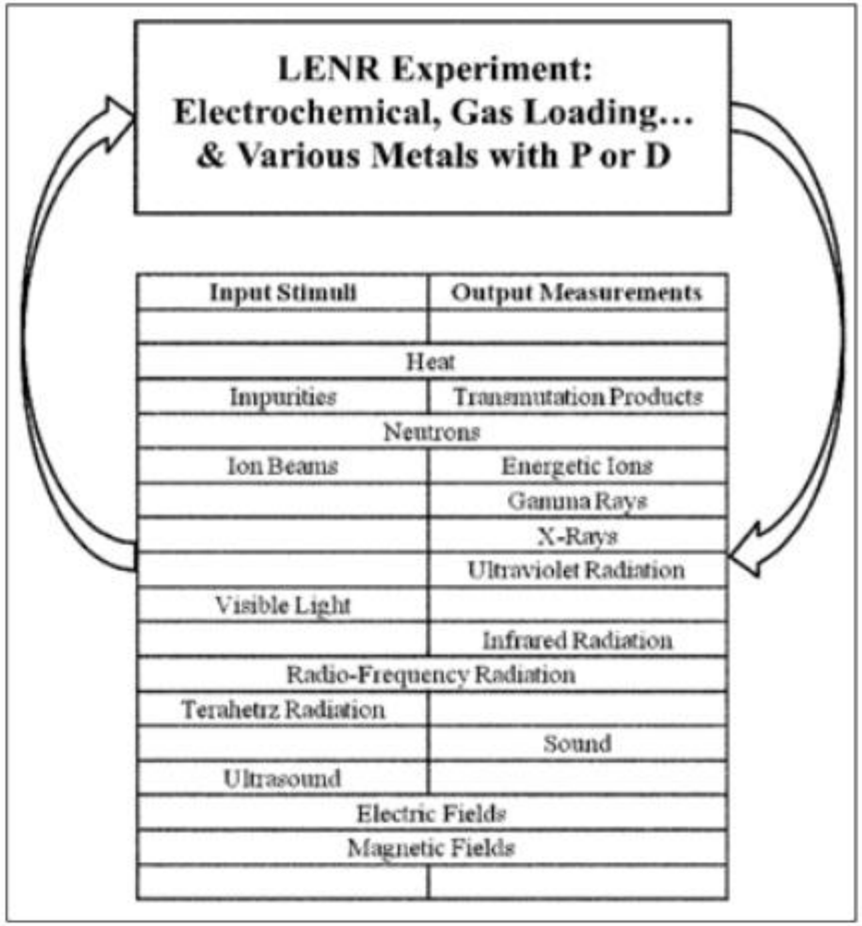
The experiments do not emit dangerous radiation during their operation.

No significant radioactive waste has been observed after LENR experiments.

LENR do not produce greenhouse gases.

Imagine a matrix of LENR theories vs empirical observations that must be explained.

Application of External Electromagnetic and Magnetic Fields Sometimes Increases the Production of Energy by LENR.



Schematic relationship between LENR experiments,
the various input stimuli that have been applied to them (left column) and
the diverse attempted output measurements from them (right column).
Blanks in the columns are possibilities that have not yet been applied or measured.
P stands for protons and D for deuterons.

The Ultimate Question: Is Your Theory Testable?

It is widely accepted that failure to achieve the results predicted theoretically does not rule out a theory, because the experiments might have some type of unknown or unrecognized flaw.

Agreement between (quantitative) theoretical predictions and the results of measurements increases the probability that a theory is correct, but even this could be accidental and worthless.

Another BASIC Question: Can all LENR observations be explained by one theory?

LENR experiments have produced a GREAT variety of observations. Are they all due to one mechanism, or are multiple mechanisms needed understand all of the data? If the latter, what controls the pathway and outcome of any given experiment?

Conclusion

Theory has only two functions:
to explain the past or to predict the future.

There is a large volume of data from LENR experiments,
which begs quantitative, or even qualitative, understanding.

Design of experimental tests of theories
is a time-honored and useful approach in the sciences.
Very few LENR theoreticians have designed experiments.

**Almost all extant LENR theories fall short
of what is desirable, and actually necessary,
in terms of their completeness.**