The Big Picture of Low-Energy Nuclear Reaction Research

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INTRODUCTION

This paper is part of the panel session "Discussion of Low-Energy Nuclear Reactions." This paper will introduce, and for some people re-introduce, the topic of low-energy nuclear reaction research. LENR research shows a surprising variety of nuclear phenomena and nuclear energy release at or near room-temperature and pressure without the need for high-energy physics or radioactive starting materials.

Significant foundational work on this topic dates to the 1920s. The modern era of this field began in 1989 when electrochemists B. Stanley Pons and Martin Fleischmann announced that they had overcome the Coulomb barrier at room temperature and triggered nuclear fusion. It turns out they didn't discover "cold fusion," but they did extend the earlier work and make some significant discoveries, even if, at the time of their announcement, they didn't understand the underlying physics.

The next significant phase in the field occurred between 1996 and 2006. During this time, experimental findings emerged to show that, although the set of phenomena is indeed nuclear, it has little or nothing to do with fusion. In 2006, Lewis Larsen and Allan Widom clarified the matter when they published a groundbreaking theory that explains the experimental LENR findings as weak interactions coupled with neutron-capture processes, without the need to invoke "new physics" or miracles.[1]

Based on the latest theoretical insights and experimental findings, LENRs are weak interactions and neutron-capture processes that occur in nanometer- to micron-scale regions on surfaces in condensed matter at room temperature. Although nuclear, LENRs are not based primarily on fission or fusion, both of which involve primarily the strong interaction.

LENRS 100 YEARS AGO

Nuclear changes at low energies were studied a century ago by a variety of scientists, most notably two American chemists, Clarence E. Irion and Gerald L. Wendt. At an American Chemical Society meeting on March 11, 1922, they reported a series of exploding-wire experiments, the best of which resulted in the formation of a cubic centimeter of helium from half a milligram of tungsten wire as the result of an intense electrical discharge passed through the wire. [2]

Four years later, in 1926, Friedrich Adolf Paneth and Kurt Peters of the University of Berlin experimented with hydrogen and palladium.[3] They reported the transmutation of hydrogen gas into small amounts of helium, based on the use of finely divided palladium. A few months later, Paneth published a letter and stated that his instrumentation was not as sensitive as he had previously thought and that it was possible that the experiment did not work as he claimed. However, he also reported data from new experiments that confirmed a direct cause-response relationship. He noted that he observed helium spectra only when he ran the experiments with hydrogen and palladium, and he did not observe helium spectra when he ran control experiments without either of these materials.

In 1929, another German, Alfred Coehn, a physics professor at the University of Göttingen, also did research on currents running across palladium wires in the presence of hydrogen gas. Percy Bridgman, a professor of physics at Harvard, Nobel Prize winner and teacher of Robert Oppenheimer, published studies in the 1930s on cold explosions. Researchers ceased this line of inquiry in the 1930s at the same time as Hitler seized control of Germany.

In 1948, this earlier body of work attracted the interest of 21-year-old Martin Fleischmann, an electrochemist at Imperial College in London. Fully aware of the potentially controversial nature of the work, Fleischmann waited until 1983, when he retired from academia, to begin those types of experiments and he joined Pons as a guest in his University of Utah laboratory. In 1989, he and Pons went public and re-sparked interest in the field.[4]

IT'S NUCLEAR BUT NOT FUSION

People who have not followed the field recently will be surprised to know that a growing number of researchers have concluded that LENR phenomena are nuclear but not the result of fusion. Experimentally, the results never exhibited the signatures of fusion, though this is obviously much easier to see in hindsight than it was 23 years ago.

Deuterium-deuterium fusion always produces results that split into three branches, the first two with nearly 50 percent probability. These two branches are not seen in LENRs. The first branch of deuterium-deuterium fusion always produces a high flux of neutrons. In LENRs, neutrons, typically observed in bursts, have been detected only occasionally. The second branch of D+D fusion always produces tritium. In LENRs, tritium has been seen on numerous occasions but only intermittently. In D+D fusion, tritium is produced at a 1:1 ratio to the neutrons. In LENRs, when tritium is found, it is measured at a million times more than the number of observed neutrons. In D+D fusion, helium-4 is found at 10 million times less than the number of neutrons and is always accompanied by a deadly gamma ray. When helium-4 is found in LENR experiments, it is found at 10 million times more than the number of neutrons and without the accompanying gamma. In D+D fusion, hydrogen is present only as a trace impurity. LENR experiments with nearly pure hydrogen show evidence of nuclear heat.[5]

In LENRs, two signatures of transmutations are observed: the appearance of new elements that were not present in the sample before the experiment and isotopic shifts in existing elements. These are not typical signatures of fusion. All of these phenomena, however, are consistent with weak interactions and neutron-capture processes.

IT'S NOT JUST ELECTROLYSIS

Another significant fact has emerged in the last few years: Although the 1989 phase of LENRs began with low-voltage electrolysis experiments, LENR researchers have employed at least 19 significant experimental methodologies since 1989, many having nothing to do with electrolysis. Although low-voltage electrolysis has been a favorite for its relative simplicity and low cost, it has been the least effective in producing significant new results and revealing new knowledge.

- Electrolysis in Heavy or Light Water
- Electrolysis with Low-Power Laser Beams
- Plasma Electrolysis
- Electrolysis with Thin Films in a Packed Bed
- Electrolytic Co-Deposition
- Gas Loading on Metal Bars
- Gas Loading on Metal Powder
- Gas Plasma - Glow Discharge
- Gas Permeation Through Thin Films
- Gas Permeation Through Thin Metals
- Exploding Wires
- Electrodiffusion
- Electron Beam Impact
- Sonic Implantation
- Biological Processes
- Electromigration Through Proton Conductors
- Hydrogen Loading of Phenanthrene
- Carbon Arc Experiments

FIELD HOLDS PROMISE

Although the research in the last 23 years has faced many challenges, limitations and misunderstandings, the database of experimental evidence, some of it performed quite well, continues to show that a new field of science has appeared that may lead to previously unimagined materials technologies and energy solutions. The experiments have consistently shown that heavy shielding from prompt radiation is not needed and that long-term radionuclides are not created.

There are no commercially capable LENR devices. Deuterium-palladium electrolytic experiments designed to produce excess heat have, at best, produced a few Watts intermittently for very short periods. During the 1990s, a few hydrogen-nickel gas-phase experiments, which could not be repeated easily, produced tens of Watts continuously for many months. [6]

In the last few years, the field has experienced limited growth. Many of the older participants remain wedded to the old paradigm of "cold fusion." Many of them work independently and lack the necessary technology and tools that are more readily available in institutional laboratories. As the general understanding of this field reaches a wider audience, more rapid progress may lead to an energy and technology revolution.

REFERENCES

1. Y. SRIVASTAVA, A. WIDOM AND L. LARSEN, "A Primer for Electro-Weak Induced Low Energy Nuclear Reactions," *Pramana - J. of Physics*, **75**(4) 617 (2010).
2. G.L. WENDT AND C.E.IRION, "The Decomposition of Tungsten to Helium," *J. of the Amer. Chem. Soc,* **44**(9), 1887 (1922).
3. F. PANETH AND K. PETERS, "Ueber die Verwandlung von Wasserstoff in Helium," *Berichte der Deutschen Chemischen Gesellschaft*, **59**(8), 2039 (1926).
4. M. FLEISCHMANN, S. PONS, M.W. ANDERSON, L.J. LI AND M. HAWKINS, "Calorimetry of the Palladium-Deuterium-Heavy Water System," *J. of Electroanalytical Chemistry,* **287**, 293 (1990).
5. S.B. KRIVIT, "Development of Low-Energy Nuclear Reactions Research," *Nuclear Energy Encyclopedia,* Steven B. Krivit, Editor-in-Chief, Jay H. Lehr, Series Editor, John Wiley & Sons (2011).
6. E CAMPARI et al., "Overview of H-Ni Systems: Old Experiments and New Setup," Presented at the 5th Asti Workshop on Anomalies in Hydrogen- / Deuterium-Loaded Metals, Asti, Italy, (2004)