What fusion theory must explain

by Hal Fox

Excellent scientific work is being done to prove the reality of cold fusion. As aptly put by Texas A&M scientists: "We are aware that, according to the classical theory of nuclear physics, when D-D [deuterium-deuterium] fusion occurs, the rate of neutron production should be approximately equal to that of tritium. This is not observed in the present experimental program. We believe that it is important firstly to establish the facts about tritium production on electrodes. The theory of electrochemical confinement will be discussed elsewhere."[1]

The purpose of this article is to review the various scientific observations that have been made in support of solid-state fusion that now must be explained by any comprehensive theory.

Neutron production from deuterated crystals. Neutrons have been shown to be generated when deuterated dielectrics are fractured. Deryagin, et al.[2] reported in 1985 the production of neutrons when heavy ice from D_2O was fractured. The same scientists reported in 1989 the production of neutrons from the fracture of titanium.[3]

Neutron production increase in liquid nitrogen. Neutron production is shown to increase when experiments are cooled in liquid nitrogen.[3]

Neutron production in electrochemical cells. Many scientists have shown the neutrons are produced in an operating electrochemical cell. Fleischmann and Pons[4] observed neutrons above background with the use of inadequate equipment and later withdrew the results. Wolf, et al.[5], at Texas A&M, not only measured neutrons but later showed that some degree of control can be exercised over the nuclear reaction that produces neutrons (personal communication). Jones, et al. at Brigham Young University, have firmly established that cold fusion exists in metal lattices in electrochemical cells solely on the basis of the measurement of neutrons.[6]

Tritium production. Many workers in the field have measured tritium being produced by nuclear reactions in electrochemical cells. The first report was from Fleischmann, Pons, and Hawkins.[4] This report was further substantiated by Wolf, et al.[5] and more thoroughly by Packham, et al., at Texas A&M.[1] Others have measured tritium including Iyengar in India.[7]

Excess heat. At least two nuclear reactions that are occurring in the electrochemical cells have been widely demonstrated by the measurement of nuclear byproducts of neutrons and tritium. These two reactions are:

1) $D + D \rightarrow {}^3He + \text{neutron} + \text{energy}$

2) $D + D \rightarrow T + \text{proton} + \text{energy}$

As mentioned by Fleischmann, et al.[4] "The most surprising feature of our results, however, is that reactions 1 and 2 are only a small part of the overall reaction scheme and that the bulk of the energy release is due to a hitherto unknown nuclear process or processes (presumably due to deuterons)."

Many other scientists, including Oriani, et al.[8] have shown that there are significant amounts of excess heat that have been measured. Others that have measured excess heat are Huggins,[9] and Appleby.[10]

Cell configuration for selected nuclear reactions. It has been reported by Dr. Kevin Wolf (personal communication) that the use of a platinum anode seems to favor neutron production—reaction (1)—while the use of a nickel anode seems to favor tritium production—reaction (2).

In addition, Dr. Wolf has observed that for a specific configuration of electrochemical cell (in which neutrons were being measured) that increasing the current above 150 mA/cm sq through the palladium cathode stopped the production of neutrons.

Dr. Glen Schoessow, working at the University of Florida in Gainesville, has been quoted as claiming to be able to control the nuclear reactions in a fusion electrochemical cell.

The theory of nuclear fusion, as it develops, will be expected to explain these observed phenomena.

Nuclear reactions in titanium. Several scientists have found that titanium, after being loaded with deuterium gas, will produce neutrons or show bursts of neutron production. Reference 3 involved fracturing the titanium. Ninno, et al.[11] in Frascati, Italy, performed experiments in which titanium was loaded with deuterium gas at about 50 atmospheres pressure, cooled to liquid nitrogen temperatures and allowed to warm up. Iyenyar[7] reports on loaded titanium disks placed between sheets of x-ray film where the tritium formation and decay exposed the film.

The theory will need to explain why the neutron production occurs sporadically and is a function of chilling and warming.

Nuclear reactions involving lithium. Dr. John Appleby aptly characterizes the experiments as "on palladium and deuterium in the presence of lithium." In Reference 10,

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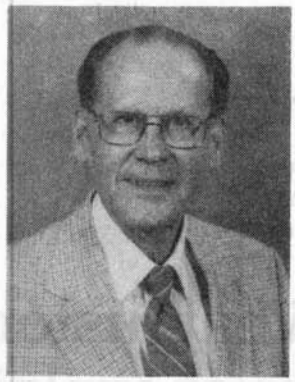

The author, an engineer, was the director of the first research laboratory at the University of Utah Research Park. When Drs. Fleischmann and Pons made their announcement of the discovery of cold fusion, Fox and a group of engineers and scientists recognized the future need for commercializing the technology. Within three weeks, this group formed the Fusion Information Center, Inc., rented office space at the University of Utah Research Park, and began publishing a monthly bulletin, *Fusion Facts,* that has rapidly become the main source of public information on who is doing what in cold fusion.

Fox and others at the Center have been working on applications for the current low level of heat obtained from cold fusion cells. They have noted the following possibilities: hot water heaters for homes, apartments, and industry; generation of low-pressure steam for sanitation purposes; heating and cooling of homes, greenhouses, farm buildings, and so forth; pumping of irrigation water; desalination of brackish and salty water; water distillation systems (for obtaining potable water at sea, for example); sewage treatment systems; heating systems for chemical processing (such as in oil refineries); food processing systems (cooking); food drying or dehydration systems; frost prevention systems for orchards; and snow removal systems—permanently installed in sidewalks and roads.

By coupling fusion energy reactors to systems for the conversion of heat energy to mechanical or electrical energy, many more applications are feasible. For example: small power plants for rural or recreational use; direct thermoelectric conversion systems; power systems (probably with batteries) for small automobiles; emergency power systems; power systems for remote operations (such as mining); and power systems for manufacturing plants.

The cost for fusion power systems may be relatively high, Fox says. However, the cost of fuel (the deuterium in heavy water) is currently about 1¢ for the energy equivalent of a gallon of fuel oil or gasoline. This is the key factor driving the intense interest in fusion energy systems.

Appleby, et al. report an experiment in which sodium deuteroxide is used to replace lithium deuteroxide in a fusion cell (while it is producing measurable excess heat). The results are very low (but above zero) excess heat. When the lithium deuteroxide is restored, the cell regains its production of excess heat.

Experiments are needed in which it is determined if lithium is involved in a nuclear reaction or whether lithium acts as a catalyst. The theorists will need this type of specific information to help in the development of a comprehensive theory.

Neutron and tritium branching. In high-energy nuclear physics, the nuclear reactions (1) and (2) above have been observed to occur with about equal frequency. Although Oppenheimer[12] discussed the branching problem in 1935, there are many highly trained scientists who expect to find equal branching of the two nuclear reactions in the low-energy palladium lattice. (Note the quotation in the first paragraph.)

Many of the scientists who have successfully replicated the Fleischmann-Pons Effect have found that equal branching of the two deuterium reactions was not observed. In fact, experiments have demonstrated that it is much easier to build a working-fusion cell that produces tritium than to obtain neutrons.

References 4, 5, and 7 all report the unexpected results that tritium production exceeds neutron production.

Tritium is found in volcano gases. The theory of cold fusion should explain the fact that tritium is found in gases from volcanoes.[6]

No reports of helium in palladium lattice. Further experimental verification will be required. However, at the present, there are no known papers in which helium-3 or helium-4 has been found to be present in the palladium lattice or in the fusion cell electrolyte in sufficient amounts to be compelling evidence of fusion byproducts. One case has been reported (Bockris in a speech given at the University of Utah) in which the level of tritium first rose and then almost exponentially decreased.

It has been suggested (Collins, personal communication) that the helium gases that may be formed from one or more nuclear reactions are being rapidly scavenged by other, as yet unreported, nuclear reactions. This may be the reason for the reduction of tritium in at least one experiment.

Bursts of short- or long-term heat. Bursts of heat have been observed by many investigators, including Fleischmann et al.[4], Iyengar,[7] Oriani,[8], and Wadsworth.[13] These bursts of nuclear activity turn themselves "on" and "off" and may last from a few minutes to several days. The effect is not as yet understood.

Summary

The above list is long, but all of these observations are either well documented or are being prepared for peer review and publication. In most cases, the scientists cited are continuing their investigations, and therefore, the name should be used in any literature research. To those scientists working in the new and exciting field of cold fusion, these are the facts that they have observed. These scientists are rapidly expanding the facts about cold fusion and relation phenomena.

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Experiments show anomalies occurring

The remarks excerpted below were delivered at a press conference following a workshop on Anomalous Effects in Deuterated Materials sponsored by the National Science Foundation and the Electric Power Research Institute on Oct. 18, 1989 in Washington, D.C.

Dr. Paul Werbos, National Science Foundation. The idea for this workshop originated in some conversations between EPRI and NSF months ago and then we decided we needed some very highly credible people, who were balanced, to chair the panel. We were very delighted that John Appleby and Paul Chu from Texas A&M and from the University of Houston agreed to serve as the chairmen. You probably have all heard of Paul Chu's work in high-temperature superconductivity, and you've probably heard of John Appleby's work in fuel cells, [which] is internationally known and very well recognized. It was their responsibility to lead the technical members of this workshop to produce conclusions we would find useful. The session was not very widely publicized in advance, for a number of reasons. First, we were not seeking publicity. Our goal was just to have a small, little research planning session—the kind of thing NSF does every day of the week, and the goal was to try to assess the general state of the field. Even more importantly, to figure out what kinds of new research might or might not be justified in this area. This workshop was not intended to be an endorsement of cold fusion. It was not intended to be a debate about the reality of cold fusion. NSF does not have an official position of whether cold fusion is or is not real. . . . The statement was written jointly by John Appleby and Paul Chu. . . .

Dr. Thomas Schneider, Electric Power Research Institute. [W]e were not asking participants to address questions about practical usefulness of the phenomena. Indeed, meaningful speculation on that topic is just not appropriate at this point. We do not have enough information to really pursue that topic. In fact, the phenomena reflect a lack of understanding about aspects of both electrochemistry and physics which