The TNCF Model
A Phenomenological Model for the Cold Fusion Phenomenon

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Synopsis:

The basic concepts of the TNCF model explaining cold fusion are presented with some examples of analysis of typical experimental data of the excess heat, tritium and helium generation and the nuclear transmutation observed in the cold fusion phenomenon. The nature of the model is illustrated in connection with other famous models in physics. The fundamental assumptions of the TNCF model: trapping of thermal neutrons in the solid and its stabilization by the interaction with lattice nuclei, are discussed briefly using conventional physics.

1. Introduction

The TNCF model was proposed three years ago[1] as a way to interpret the confusing experimental data presented by the cold fusion phenomenon. After the announcement of its discovery[2], world-wide controversy ensued. The fundamental cause of the controversy was the conceptual barrier for understanding the new phenomenon and secrecy around the patent barrier. As a matter of science, the former is more important which stubbornly assumed that the cold fusion in materials with hydrogen isotopes at room temperature should be induced by the same nuclear reactions as those at high energy in a vacuum. Many physicists refused to accept the experimental data which were characterized by low reproducibility and by an apparent inconsistency of observed events with a conventional view of particle physics.

It is instructive to remember typical models in the history of science which at first were ridiculed, even though they explained the new experimental results which contradicted old concepts. For instance, to cite two examples, the Bohr model for hydrogen atom and the two-fluid model of the superfluidity of liquid helium are typical ones. The Bohr model explained the atomic spectra of hydrogen and the finite size of it with the assumption that there are stationary electron orbits, even though they contradicted classical electrodynamics.

Later, these assumptions were systematized as Quantum Mechanics, an entirely different physics from classical one.

The two-fluid model was proposed to explain the experimental data of superfluidity of liquid helium, assuming a new concept of a superfluid which has no viscosity at all. This new concept contradicted the old concepts of a classical fluid, but it explained the experimental data and predicted the existence of the second sound, which was discovered later experimentally.

Thus, a good model is very effective in helping to promote science if it systematizes a perplexing pile of experimental data, even if its basis is ambiguous for a while. The TNCF model is a phenomenological one developed to explain the complex experimental data of the cold fusion phenomenon. Since a majority of scientists, especially physicists, have been deeply sceptical of the reality of cold fusion, their not having made a thorough investigation into it for them themselves, this model should be helpful.

2. Characteristics of the TNCF Model and An Explanation of Some Typical Experimental Data

The TNCF model has been applied to analyze more than forty experimental data which has been reported by experimenters. The results were published also in compiled forms[3-6]. The fundamental assumptions of the TNCF model, similar in its nature to the stationary electron orbits in Bohr's model of hydrogen atom and the superfluid in the two-fluid model of liquid helium, are the existence of quasi-stable neutrons in cold fusion materials and their reaction with nuclei, resulting in a large influence on them.

In the model there is one adjustable parameter n_n, the density of the trapped thermal neutron, which is used to analyze the cold fusion phenomenon with several events specified by some physical quantities supposed to be results of various physical processes in the material. Some examples of these quantities are (1) gamma ray spectra, neutron energy spectra and distribution of transmuted nuclei in the material and (2) the excess heat, amounts of generated tritium and helium in a given time, X-ray and other charged particles, if any. The quantities in group (1) are evidence which provides direct information of the events and those in group (2) indirect.

There are some premises[4-6] which connect n_n and the observed quantities which are summarized as follows: The quasi-stable trapped neutron is stable against the destined beta disintegration in its free state and also against fusion with one of nuclei in the metal lattice points (lattice nuclei). The neutron in a material can fuse with a nucleus, for instance, in the surface layer which works as a reflector of the neutron back into the material. The fusion cross section in this case is assumed the same as that in vacuum.

With these assumptions, more than forty typical experimental data, including those by Fleischmann et al.[2], Morrey et al.[7], Miles et al.[8], Storms et al.[9], Gozzi et al.[10] and Bush et al.[11] were analyzed and found consistent with this model. The results[12-15] are summarized as follows: In the pioneering work[2] where excess heat, tritium and neutron in the electrolytic system with Pd cathode in D_20 + LiOD electrolytic solution (Pd/D/Li system) were observed, the controversial relations between these quantities were interpreted using our model[12] with our consistently seeing values of $n_n = 10^7 \sim 10^9$ cm^{-3} (if we permit an inconsistancy in the experimental results which showed a lack of an expected simultaneity of events from the model).

The difficulty of explaining the production of ^{4}He in the electrolytic system of Pd/D/Li[2,7,8] was resolveti by the reaction between the trapped neutron and ^{6}Li

$$n + {}^6\mathrm{Li} = {}^4\mathrm{He} + t,$$

occurring in the surface layer of Li metal (and/or PdLi. alloy) in the cathode. The parameter n_n was determined[12] from the data in these experiments as $10^8 \sim 10^{10}$ cm^{-3}.

In the experiment[9] where excess heat and tritium in Pd/D/Li system, but without expected simultaneity was observed, the parameter n_n was determined[13] as $10^7 \sim 10^{11}$ cm^{-3}, with the same reservation for the simultaneity of events. The experiment[10] where excess heat, tritium and ^{4}He in Pd/D/Li system were observed, the data were interpreted[14] with $n_n = 10^{10} \sim 10^{11}$ cm^{-3} consistently, but again with the same reservation for the expected simultaneity of events.

In the experiment[11] with Ni cathode and $H_20 + Rb_2CO_3$ electrolytic solution, excess heat and a nuclear transmutation from ^{85}Rb to ^{86}Sr were observed. The result was explained by the TNCP model[15] with $n_n = 1.4 \times 10^7$ cm^{-3}.

Thus, it is possible to interpret various, sometimes more than two events in the cold fusion phenomenon assuming only one adjustable parameter n_n with a reservation of the inexplicable problem of poor reproducibility and a lack of simultaneity of events. To understand these unexplained points more clearly it will be necessary to look at the details of the materials into the TNCF model.

3. Physical Basis of Premises in the TNCF Model

The fundamental assumptions of the quasi-stable existence of the trapped neutron

has been supported by the success of the explanation of the experimental data which is impossible to understand using conventional physics. The success itself shows the reality of the assumed quasi-stable neutrons trapped in materials which exhibit the cold fusion phenomenon. It is, however, desirable to investigate the quasi-stable neutron theoretically to develop a physical understanding of the cold fusion phenomenon and to predict the new effects expected from its nature, thus enabling us to construct a new physics — the solid state — nuclear physics. Several key problems about presumptions in the TNCF model are considered in this section.

First of all, there is the question of where the trapped neutron comes from.

A probable primary source may be the environmental neutron which are plentiful, produced by cosmic ray in upper air at high altitude. The environmental neutron causes troublesome background for measurements and make the neutron observation ambiguous, as we who have worked with them well know. There are evidences that the cold fusion phenomenon has not been observed in a low background environment. Another evidence of the above interpretation of the source of the trapped neutron is the aging effect and the long prerun effect to initiate the cold fusion phenomenon. This could be considered as the result of a process for supplying the necessary amount of trapped neutrons from the environment. After gathering the minimum amount of the trapped neutrons, the reactions[3-5] such as the reaction (1) will supply enough neutrons to the material.

The second question for the TNCF model is the mechanism for neutron trapping in materials. We have proposed several mechanisms for it. The most effective and realistic one from our present knowledge of the situation where cold fusion occurs is the band structure effect[4,16]: different neutron bands in adjacent materials keep the trapped neutron from passing though the boundary between them if an allowed band in one and a forbidden band in another coexist at the same energy.

The third question is the quasi-stability of the trapped neutron against the beta decay and also against the fusion with the lattice nuclei in the material. To understand this concept it is helpful to remember the stability of a neutron in a nucleus, e.g. in a deuteron. The neutron in the deuteron is stable in the same meaning as above due to a nuclear interaction with a proton in it. Similarly, a neutron trapped in a material as a Bloch wave could be stable due to the unclear interaction with lattice nuclei. To investigate experimental data from our point of view, a new concept of the "neutron affinity" of a material was proposed[16,17] which shows a positive correlation with experimental data.

It is taken as a matter of course that these ideas introduced to explain the possible existence of the quasi-stable trapped neutron in an appropriate material with some characteristics (which are manifested experimentally) should be verified experimentally by observations of the predicted phenomena using the model[18].

Recently, it has been shown that a reduction of radioactivity of some radioactive nuclei, e.g. Th, occurs in the electrolytic system in the cold fusion experiment[19]. Though the details of these effects have not been described in published papers, it is possible to contemplate possible causes of the effect, assuming its reality: The ion of a radioactive element dissolved into electrolytic solution will deposit on the cathode in the process of electrolysis, just as the ion of the alkali metal in electrolyte (as Li^+, K^+ and so on), which is a key element in the electrolytic experiment from our point of view. The radioactive ion on or in the surface layer interacts with the trapped neutron to fuse with it, resulting in some reactions and the stabilization of the nucleus with emission of soft gamma ray or nuclear transmutation by emission of particle(s). The reduction of radioactivity could be interpreted using the TNCF model as above.

To clarify these possibilities, it is desirable to check the nature of the reduction of radioactivity experimentally: whether it is only the result of deposition of radioactive element on the cathode or is the result confirmed by the sum of whole element in the system, whether the reduction occurs on the cathode and then flow out into the solution or in the solution, and so on.

4.Conclusion

The cold fusion phenomenon, consisting of the generation of excess heat, tritium, helium, gamma rays, neutrons, transmuted nuclei in materials at near room temperature is very complex. Its poor reproducibility, the sporadic nature of events, the inconsistency of predicted events, the variety of materials showing it, and so forth, add to the complexity. To investigate such a phenomenon experimentally and theoretically, it is desirable to have a solid standpoint as a first position from which further development can be started.

A new phenomenon as a rule demands a new point of view, as we have many examples in history as illustrated in the first section of this paper by the Bohr's model of hydrogen atom and the two-fluid model of superfluidity. We have to find a missing factor[20], not noticed until now, to explain the new phenomenon known as cold fusion (we can use this term until we determine the nature of the phenomenon more clearly).

There are several successful applications of the cold fusion phenomenon: to generate the excess heat[21,22], to reduce radioactivity[19] and so on. Technology usually goes first, then science follows it, as history has shown, with the steam engine being typical. The invention of the modern condensing steam engine was patented in 1769 by James Watt, preceded the discovery by N.L.S. Carnot in 1824 and its proof by R.J.B. Clausius in 1850 of the Carnot's theorem by more than a half century. If scientists stay indifferent to a new phenomenon whis is difficult to understand using conventional concepts, a new technology will be used by society after a series of trial-and-error processes. To shorten the path to develop a new technology which is needed by the world we have to be sensitive to a new possibility, not only for application, but also for development of a new science which will attract intelligence of people to the creation of a new culture.

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