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THE TNCF MODEL – A PHENOMENOLOGICAL MODEL FOR THE COLD FUSION PHENOMENON

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ABSTRACT

Basic concepts of the Trapped Neutron Cold Fusion (TNCF) model for cold fusion are presented with some examples of analysis of typical experimental data on the excess heat, tritium and helium generation and the nuclear transmutation in cold fusion phenomena. The nature of the model is illustrated in connection with other famous models in physics. Fundamental assumptions in the TNCF model, trapping of thermal neutrons in the solid and its stabilization by the interaction with lattice nuclei, are contemplated briefly in terms of conventional physics.

INTRODUCTION

The TNCF model was proposed three years ago [1] to interpret the confusing experimental data in cold fusion phenomena. After declaration of its discovery [2], world-wide controversy burst into flames around cold fusion with scandalous disclosures of nonscientific affairs. Fundamental causes of the controversy were the conceptual barrier for the new phenomenon and secrecy about the patent barrier. As a matter of science, the former is more important, which dogmatically assumed that cold fusion in materials with hydrogen isotopes at room temperature should be induced by the same nuclear reactions just as those at high energy in vacuum. Many physicists denied experimental data which were characterized by low reproducibility and by apparent inconsistencies in observed events when interpreted using conventional views of particle physics.

It is instructive to recollect typical models in the history of science which at first seemed ridiculous even though they could explain new experimental results which contradicted with old concepts. We consider two typical examples, the Bohr model for hydrogen atom and the two-fluid model of the superfluidity in liquid helium. The Bohr model could explain the atomic spectra of hydrogen and finite size of it on the assumption that there are stationary electron orbits even though these orbits contradicted classical electrodynamics. Later, these assumptions were systematized as Quantum Mechanics, which is entirely different from classical physics.

The two-fluid model was proposed to explain the experimental data of superfluidity in liquid helium. This model assumes a new concept of super-fluid which has no viscosity at all. This new concept contradicts the old concept of classical fluid but is able to explain the experimental data and predicts the existence of the second fluid state which was discovered later experimentally.

Thus, a good model is very effective if it can systematically account for perplexing experimental data even if its basis is ambiguous for a while. The TNCF model is a phenomenological one which tries to explain complex experimental data in the cold fusion phenomenon. A majority of scientists, especially physicists, who have not thoroughly investigated the matter, are presently skeptical towards cold fusion.

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Characteristics of the TNCF Model and Explanation of Some Typical Experimental Data

The TNCF model has been applied to analyze more than forty sets of data from experiments until now obtained in various circumstances and materials. 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 existence of quasi-stable neutrons in cold fusion materials and their selective reaction with some nuclei.

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 definite time, X ray and other charged particles if any. The quantities in group 1) are direct evidences having 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 on the lattice points (lattice nuclei). The neutron in a material can fuse with a nucleus, for instance, in the surface layer which reflects the neutron back into the material in a classical sense. The fusion cross section in this case is assumed to be the same as that in vacuum.

With these assumptions, more than forty typical experimental facts 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 successfully with consistent results. The results [12~15] are summarized as follows: In the pioneering work [2] where excess heat is observed, tritium and neutrons in the electrolytic system with Pd cathode in D_2O + LiOD electrolytic solution (Pd/D/Li system), the controversial relations between these quantities were interpreted by our model [12] consistently with values of $n_n = 10^7 \sim 10^9$ cm^{-3} if we permit inconsistency in the experimental results which showed lack of expected simultaneity of events from the model.

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

$$n + 6\ \mathrm{Li} = {}^4\mathrm{He} + t, \qquad (1)$$

occurring in the surface layer of Li metal (and/or $PdLi_x$ alloy) on 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 is observed in Pd/D/Li system but without expected simultaneity, 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 were observed in Pd/D/Li system, the data were interpreted [14] with $n_n = 10^{10} \sim 10^{11}$ cm^{-3} consistently altogether but again with the same reservation for the expected simultaneity of events.

In the experiment [11] with Ni cathode and H_2O + Rb_2CO_3 electrolytic solution, the excess heat and a nuclear transmutation from ^{85}Rb to ^{86}Sr were observed. The result was explained consistently by the TNCF 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 consistently assuming only one adjustable parameter n_n with a reservation of inexplicable problem of poor reproducibility and lack of simultaneity of events. To understand these unexplained points more clearly, it will be necessary to take details of the object materials into the TNCF model.

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 in the explanation of the experimental data impossible to understand in the frame of conventional physics. The success itself shows previously the reality of the assumed quasi-stable neutrons trapped in materials which cause the cold fusion phenomenon. It is, however, desirable to investigate the quasi-stable neutron theoretically to develop physical understanding of the cold fusion phenomenon and to predict new effects expected from its nature if possible which will enable one to construct new physics -the solid state - nuclear physics. Several key problems about presumptions in the TNCF model are contemplated in this section.

First of all, it is questioned where the trapped neutron comes from. A probable primary source may be the environmental neutron which is very popular on the earth produced by cosmic ray in upper air at high altitude. The environmental neutron causes troublesome background for the measurement and make the neutron observation ambiguous, as we know well. There are evidences that the cold fusion phenomenon has not been observed in low background environment. Another evidence of the above interpretation of the source of the trapped neutron is the aging effect and the long pre-run effect for realization of the cold fusion phenomenon. These effects could be considered as results of a process for accumulation of a necessary amount of the trapped neutrons in materials from environment. After the piling up of minimum amount of the trapped neutron, the trigger reactions [3~5] such as the reaction (1) will feed a sufficient number of neutrons to the material.

Second question for the TNCF model is the mechanism of neutron trapping in materials. We have proposed several mechanisms for it. The most effective and realistic one based on present knowledge of the situation where cold fusion is the band structure effect [4,16]: difference of neutron bands in adjacent materials makes the trapped neutron impossible to pass though the boundary between them if an allowed band in one and a forbidden band in another coexist at the same energy.

Third question is the quasi-stability of the trapped neutron keeping it from beta decay and also from fusing with lattice nuclei in the material. To understand this concept, it is helpful to remember 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 nuclear interaction with a proton in it. Similarly, a neutron trapped in a material as a Bloch wave could be stable due to the nuclear interaction with lattice nuclei. To investigate experimental data from our point of view, a new concept "neutron affinity" of a material was proposed [16,17] which has positive correlation with experimental data.

It is taken as a matter of course *that* these ideas introduced to explain 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 by the model [18].

Recently, it is remarked that reduction of radioactivity of some radioactive nuclei, e.g. Th, occurs in the electrolytic system for 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; 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 by the TNCF model as above.

To clarify these possibilities, it is desirable to check the nature of the reduction of radioactivity scientifically: 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.

Conclusion

The cold fusion phenomenon consisting of generation of the excess heat, tritium, helium, gamma ray, neutron, transmuted nuclei in materials at near room temperature is very complex with its poor reproducibility, sporadic nature of events, inconsistency of the observed events with prediction, variety of materials showing it, and so forth. To investigate such a complex phenomenon experimentally and theoretically, it is desirable to have a solid stand point, if any, as a first small hold from which further development can be started.

A new phenomenon as a rule demands a new point of view. We have many historical examples which have been described in the first section of this paper, by Bohr's model of the hydrogen atom and the two-fluid model of superfluidity. We have to find out a missing factor [20] not noticed until now to explain new phenomenon known as the cold fusion phenomenon (it is tolerable to use this word so popular now until we determine the nature of the phenomenon clearly because we do not know at all about it).

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 is usually developed first, then science follows it, as history shows by a typical example – the steam engine: the invention of the modern condensing steam engine patented in 1769 by J. Watt preceded the discovery by N.L.S. Carnot in 1824 and its proof by R.J.E. Clausius in 1850 of the Carnot's theorem by more than a half century. If scientists remain indifferent to a new phenomenon with complex events difficult to understand from conventional concepts, the associated new technology will be used in society after a series of trial-and-error processes. To shorten the path to commercialize a new technology necessary for the present world, we have to be sensitive to a new possibility not only for application but also for the development of a new science which is reasonable and which may lead to the development of a new industry.

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