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# Characteristics of the Nuclear Reactions in the Cold Fusion Phenomenon

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## Abstract

The cold fusion phenomenon is characterized by nuclear reactions in CF materials, materials including hydrogen isotopes (H or/and D) with a high concentration, with no mechanisms to accelerate particles in them. First of all, we would like to notice that the CF materials are not confined to deuterium but also protium systems and classified roughly into two groups; (1) metallic materials include transition-metal hydrides (e.g. $NiH_x$, $AuH_x$) and deuterides (e.g. $PdD_x$, $TiD_x$), and hydrogen graphite ($HC_x$), and (2) hydrocarbons including XLPE (cross-linked polyethylene) and microorganisms including bacteria, microbial cultures and biological tissues or organs.

Looking for the common cause of nuclear reactions in these CF materials, we have to notice the characteristics of the nuclear reactions in the CFP different from the nuclear reaction observed in nuclear physics in free space. In free space, the energy difference between the initial and the final states, generally more than a few MeV, is carried out by a particle or two. The amount of this energy difference is about eight orders of magnitude larger than the thermal energy of the particles in the CF material. Therefore, it is difficult to consider the participation of environment in the nuclear reactions in the CFP.

Nuclear reactions in the CFP show, in general, no emission of high energy photons which should be observed if emitted despite of the existence of CF materials surrounding the site where the reaction occurs. Furthermore, the most wonderful events in the CFP is the generation of new elements with changes of the proton number $Z$ and/or nucleon number $A$ from those of preexisting elements in the system. We have given a self-consistent unified explanation of various events in the CFP hitherto in our books and papers. In this paper, we concentrate our investigation on the nuclear transmutations with large shifts of the proton number $Z$ and the nucleon number $A$ revealed by recent experimental data sets to illustrate the peculiarity of the CFP and to show again the ability of the TNCF model and the ND model to give consistent explanation of various events in the CFP. It should be noticed that the investigation of the premises assumed in the models have shown the decisive role of the nuclear interaction between neutrons in lattice nuclei and protons/deuterons at interstitial sites which is discussed elsewhere.

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# Inductive Logic and Meta-analysis in the Cold Fusion Research

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## Abstract

The cold fusion phenomenon (CFP) had been a wonderful and inexplicable phenomenon where occur nuclear reactions in materials composed of host elements and hydrogen isotopes (CF materials) at near-room temperature environment without any specific acceleration mechanism. The variety of the experimental data has been also mysterious to understand it in the traditional solid-state physics and the nuclear physics. To understand the complex experimental data obtained in the CFP consistently, we have to depend on the phenomenological approach with a model and then on the quantum mechanics to investigate the premises assumed in the model. We have presented a successful model (the TNCF model) for the CFP and the quantal analysis of the model has revealed participation of neutrons in the nuclear reactions in the CF materials.

Looking back to the methodology used in the explanation of the CFP by the TNCF model, we notice now that there are resemblance of the logic in the explanation of the CFP to the meta-analysis and more widely to the inductive reasoning prevalent in natural history before the science revolution in $17^{th}$ century.

It is valuable to point out the use of the meta-analysis in astronomy in $18^{th}$ century and in such complex situations in the medical science where they call the analysis “EBM” (evidence based medicine) or “Systematic Review” in modern medicine. The analysis of the data sets in the CFP performed in our phenomenological approach could be classified into the meta-analysis. It is also noticed that the logic used in our explanation of the CFP by the TNCF model is classified into the inductive rather than the deductive logic prevalent among the modern science developed after $17^{th}$ century when the Newtonian mechanics was established. In a complex system where the nonlinear dynamics governs the behavior of component particles of the system and complexity is ubiquitous, we are not able to prepare exactly the same microscopic state for a sample using even the same macroscopic experimental conditions and therefore not able to predict the effect in the system from the macroscopic initial condition. The ordinary concept of the analysis and the deductive logic fail to give a definite image and a definite history of the system. It is emphasized that the cold fusion phenomenon is just the case we have to depend on the meta-analysis and the inductive logic to describe the development of the system.

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# Development of the Solid State-Nuclear Physics (SSNP)

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## Abstract

Investigation of the cold fusion phenomenon (CFP) for about 30 years since its discovery in $PdD_x$ by M. Fleischmann et al. in 1989 has revealed existence of nuclear reactions in specific solids at near room-temperature without any mechanism of acceleration for particles in the system. The diverse and complex experimental data, obtained in CF materials including hydrogen isotopes (H or/and D) with high concentration, have been riddles for almost all scientists. The facts observed in this field, however, suggest existence of new mechanisms for nuclear reactions in such solids (CF materials) as transition-metal hydrides and deuterides, hydrogen graphite, XLPE (cross-linked polyethylene) and microorganisms. The new mechanisms for the CFP should be a fundamental element of a new physics in between solid state physics (condensed matter physics) and nuclear physics, which we may call the solid state-nuclear physics (SSNP).

We have developed a phenomenological approach with a model (TNCF Model) to the CFP to understand the complex data sets as a whole obtained in this field. The approach has been successful to give a unified interpretation for the CFP and suggests an outline of the SSNP where neutrons in the CF materials play a key role for the realization of the nuclear reactions resulting in the CFP.

In the phenomenological approach to the CFP, we used unintentionally the inductive logic and the meta-analysis of the experimental data which are not popular in modern physical sciences developed in these 300 years since the establishment of the physics based on the Newtonian mechanics, which was effectively applied to the simple systems with the linear interaction between particles. For such a system as the CF materials where nonlinear interactions govern the behavior of component particles, the inductive logic should be used and the meta-analysis is necessary to treat experimental data.

The fundamental premises assumed in the TNCF model have been explained by a new mechanism for interactions among host elements and interstitial hydrogen isotopes explained by quantum mechanics. Thus, the CFP have opened a gate to the SSNP in which the nuclear interaction between neutrons in lattice nuclei and interstitial protons/deuterons induces a new state of neutrons and they play the reading part to realize the nuclear reactions resulting in the CFP which is a new phenomenon of SSNP.