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The Sociology of the Cold Fusion Phenomenon – An Essay –

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Abstract

The history of the researches on the cold fusion phenomenon in the modern industrial society is investigated using the framework of the sociology of the science developed in the 20th century. The motivation to find out the cold fusion of deuterons in solids and the effort to establish the science of the cold fusion phenomenon (CFP) are deeply interrelated with the flows of economy and science in the history of the latter half of the last century. The foreseen deadlocks of the social development, especially the exhaustion of energy resources, have been a fear for the future of human beings. The controlled thermonuclear fusion (plasma fusion) of deuterons and tritons was taken up as a final solution for this difficulty and had grown up as a big science (or rather a huge science) since the middle of the 20th century. The CFP was taken up as an alternative to the plasma fusion which had been in a stagnant situation after 40 years since its substantial start in the beginning of 1950s. The CFP thus motivated has been destined to be an alternative to the plasma fusion in the sentiment of many researchers in this field and also in the thought of scientists in the established fields of modern science. The situation has given a biased trend in the majority of researchers engaged in the CFP to take up solely the deuterium systems and to disregard the protium systems from CF materials. This trend has given the research of the CFP a biased character and an unsound development. It need scarcely be said that it is necessary to take up whole materials obtained by experiments not only in deuterium but also in protium systems to establish the science of the cold fusion phenomenon. Overviewing the history of the CFP, we point out necessary conditions for the sound development of the science of the CFP. Possible application of the CFP will follow the realization of the science.

Key words; Cold Fusion Phenomenon, Sociology of Science, Big Science, Science and Society

Contents

Prologue – Science and Military Technique

"- - - *military exigencies have encouraged the growth of one branch of science, especially in seventeenth-century England*." [Merton 1975 (p. 204)]

The foci of scientific interest are determined by social forces as well as by the immanent development of science, as R.K. Merton expressed in his paper published in 1935 [Merton 1975 (9. *Interactions of Science and Military Technique*)]. In the social forces, the military techniques are most strong in a short term to influence the science as history has shown. We can cite sentences on this relation from Merton's paper;

" - - - Thus it appears that on the average about 10 percent of the research carried on by the foremost scientific body in seventeenth-century England was devoted to some aspect of military technology. To an appreciable extent, then, this one extrascientific concern tended to focus scientific attention upon a given body of scientific problems.
The relations between military demands and the scientific development of the time were primarily of two sorts. The first involved conscious, deliberate efforts of the contemporary scientists directly to solve problems of military technology. This is what is meant by a *direct* relation. The second type is less apparent, for it concerns scientific attention to problems which, although either imposed or emphasized by military needs, seemed to the scientists as of purely scientific interest. This was called the *indirect or derivative* relation." [Merton 1975 (pp. 208 – 209)] (Italicized at citation)

As the technology prevailed over social relations, the science had become an overwhelming factor as a source of wealth and also as an enterprise of a society. In the 19th century, Alfred Nobel already established huge wealth by his inventions of explosives used as armaments; "During his life Nobel was issued 355 patents internationally and by his death his business had established more than 90 armaments factories, despite his belief in pacifism." [Hiskey 2011] It is said that A. Nobel was named as "The Merchant of Death" in a French newspaper and had considered how to improve his public image after his death and decided on leaving his enormous fortune to fund a set of prizes named after himself.

The extravagant explosives, the atomic bomb (A-bomb) and hydrogen bomb (H-bomb) developed after 1942, are the two satanic armaments human beings ever obtained. The principle of the A-bomb is the chain reaction of the uranium fission

reactions induced by a neutron liberating the nuclear energy contained in uranium nuclei. The atomic power plant based on this principle to generate energy has been developed accompanied by the production of the A-bombs despite of scarce resource of uranium ore and of the unsolved problem how to treat the nuclear ashes.

The principle of H-bomb is the fusion of deuterons occurring in stars. The deuterium (heavy hydrogen) is contained in sea water about 1:5000 of protium (light hydrogen) and is substantially endless. If we can realize the controlled nuclear fusion reactions of deuterium on the Earth, we can get an infinite source of energy. This is the reason the controlled thermonuclear fusion program has started in 1950s worldwide and the program has been pursued for almost 70 years.

Even if A-bomb and H-bomb are satanic, they have duel characters, direct and indirect relations with science as R.K. Merton defined in the sentence cited above. The indirect effect of the study of controlled thermonuclear fusion derived from the H-bomb has induced development of plasma physics which has explained many problems of ionized gases in space and in stars as by-products. The close relation of the controlled thermonuclear fusion with the cold fusion phenomenon is discussed in the following Sections.

1. Introduction

"*A new scientific truth is not usually presented in a way that convinces its opponents . . .; rather they gradually die off, and a rising generation is familiarized with the truth from the start.*" (M. Planck, 1948 cited by T.S. Kuhn in [Kuhn 1972 (p. 81)] from his autobiography [Planck 1948]).

The Planck's sayings cited above reflects surely his experience in the development of quantum theory in the beginning of the previous century. The content of the sayings, however, has deep roots in the sociology of science common to the development of the cold fusion phenomenon (CFP) in these about 30 years. The sociological investigation of the history of the CFP is the main theme of this paper.

The history of the controlled thermonuclear fusion (the plasma fusion) research substantially started in 1950s (cf. Appendices B and C) on one hand and that of the cold fusion phenomenon (CFP) started in 1989 on the other show the overwhelming influence of the former on the latter, as shown by the sociology of the science developed in the century.

In this section, we give a brief survey of the energy problem we have confronted at present in Subsection 1.1, of the destined characteristics of science in the present

industrial society in Subsection 1.2, and of the motivations of the cold fusion research in Subsection1.3. The terminology of the cold fusion phenomenon is given in Subsection 1.4. Outline of this paper is given in Subsection 1.5.

1.1 Energy Crisis in Modern Industrial World

Search for a stable and limitless resource of energy started in the middle of 20th century – resulted in the controlled thermonuclear fusion as the most hopeful candidate (e.g. [Kozima 1998 (Chapter 14)]). The investigations of fusion reactors to realize controlled thermonuclear fusion on the Earth started substantially in 1950s. The nuclear fusion reactions supposed to be useful for the above project are written down as follows (cf. Appendix B):

$$D + D \rightarrow T\ (1\ MeV) + p\ (3\ MeV), \qquad (1\text{-}1)$$

$$D + D \rightarrow {}^{3}He\ (0.l8\ MeV) + n\ (2.5\ MeV), \qquad (1\text{-}2)$$

$$D + D \rightarrow {}^{4}He\ (0.08\ MeV) + \gamma\ (23.8\ MeV), \qquad (1\text{-}3)$$

while the third reaction is essentially ignored due to its too small branching ratio ($\sim 10^{-7}$) compared to those of the first two.

Many textbooks on the plasma physics have taken up the problem of controlled thermonuclear reactions as a motive force for the growth of this new science (e.g. [Chen 1974]).

It will be very helpful to cite the first several pages on the controlled thermonuclear fusion from the Chen's textbook to understand the situation in which new energy sources had been looked after eagerly. The first four pages of *Section 9 Introduction to Controlled Fusion* are cited in Appendix B [Chen 1974].

ITER (International Thermonuclear Experimental Reactor) project started in 1985 as an international project to explore a controlled thermonuclear fusion machine based on the TOKAMAK concept. To know the outline of the project, we cite the *ITER Story* from the ITER homepage in Appendix C [ITER 1985].

1.2 Science in the Industrial Society – The so-called "Big Science" and the Scientific Spirit

Science is a human behavior to construct an image of outside world based on the perception a man received in interaction with that world. It is sometimes supposed that the science thus constructed and described by a logical system of the human being is an objective existence accepted by all human beings. It is true as far as the constructed structure of the science is concerned. It is however necessary to remember an important factor of the science at the first stage of its formation. The science is not constructed

automatically from materials accepted by sensory organs such as eyes, ears and skin of human beings. The science is essentially an image of the outside world caught by the intuition or instinct of a human being. The image is then manipulated logically and mathematically to make objectively understandable by others. The popularization of science in modern world made the constructed science written in text books familiar and made the subtlety of the creative works obscure and invisible. We have to recollect the trial-and-error stages of scientific endeavors at its initial stage of every science which we are now accepting as established one as a matter of course.

Science and technology are called sometimes “science and technology” (science-technology complex, science-technology conglomerate) all together and supposed to be the same thing. However, they should be considered different thing. Science and technology contain the same knowledge together but differ in which they aim at. The object of the science is just to know about the target and ends its activity when it is obtained. However, the technology does not finish its activity only by knowing the target but uses it for another purpose. And for these purposes, the scientific knowledges are sometimes rearranged, i.e. “A causes B” is transformed into “To get B, find out A.” Of course, it is usual to cultivate new techniques for scientific activity but only for the scientific objects. In technology, however, the purpose of the innovation is not only for the new scientific knowledge but also for the technical application. The pile up of the technical endeavor forms a system of technical methodology different from the system of scientific methodology.

In the modern world of technological economy, the former is overwhelming the latter. The scientific spirit is diminishing as well as aesthetic and moral spirits. In the history of the cold fusion phenomenon, we see how the scientific spirit is overwhelmed by the entrepreneur desire and a science is in agony to be well-born in the world and be recognized its true value.

It is an impressive fact that the atomic power generation started after the A-bomb was used in the war in 1945. The research of the controlled thermonuclear fusion started after the H-bomb was exploded in Eniwetok in 1952. It is said sometimes “The war promotes new science and technology.” The use of nuclear power as peaceful utilization of an energy source illustrates this saying exactly.

1.3 Curiosity for Strange Events and Competition for Financial Supports

The cold fusion phenomenon is a curious one which cannot be understood by existing knowledge of modern science developed in 20th century after a revolutionary opening of

quantum physics in 1900. The field of the cold fusion phenomenon (CFP) is known as that occurred in ordinary temperature and pressure, not so high- or low-temperatures, not so high-vacuum or not so high-pressure conditions which have been explored by the end of the last century as a result of pursuance of novel phenomena such as superfluidity, superconductivity, new states of matter. However, there are many, many events wonderful for the eyes accustomed to phenomena observed in the established fields of modern science; the most wonderful one may be the nuclear transmutations in CF materials including transition-metal hydrides and deuterides, hydrogen graphite, cross-linked polyethylene (XLPE) and microbial cultures as explained in our books (e.g. [Kozima 2006]) and papers (e.g. [Kozima 2016a]). The data sets as a whole, especially the three empirical laws found between observables, have shown that the CFP is a phenomenon to be considered as complexity.

In these 25 years after the discovery of a part of the CFP in 1989 by Fleischmann et al. [Fleischmann 1989], there have been piled up many data sets showing various phases of this phenomenon and some of them have been checked by eyes of critical scientists concluding something true are in them in reality [DOE 2004]. Even then, there is no recognition of reality of the CFP in the researchers in this field and also in scientists in established fields in the world. One of the reasons that the former has been losing the point is their persistence in the Fleischmann's hypothesis which is favorable for its application of the CFP. The most important cause that the latter has lost their reason is not so simple but understandable from a viewpoint of social science of history.

Thomas S. Kuhn explored a new viewpoint in the history of science to understand the changes of scientific entrepreneur in history using a word "paradigm." [Kuhn 1962] According to his terminology used in the history of science, we extend its usage to scientific research activity in process and apply it to the evaluation of the CFP, a part of it was discovered in 1989 and developed by the trial and error method until now, as a process of formation of a new paradigm between traditional nuclear physics and solid-state physics. This viewpoint gives us a new bird's-eye view of the CFP which is useful to understand the situation we are placed in it.

It is possible to say that "A science starts its life when a new fact is (be) recognized to contradict existing paradigms."

In close relation to the characteristic of science in the modern society, the revolution of science characterized as "the paradigm change" had specific nature. We can depict the nature of the CFP as a new paradigm using several sentences from T.S. Kuhn [Kuhn 1962];

"In the absence of a paradigm or some candidate for paradigm, all of the facts that could possibly pertain to the development of a given science are likely to seem equally relevant." [Kuhn 1962 (p. 15)]

The CFP was a product of a scientific mind to search a new possibility of deuteron fusions naturally confined in solids assisted by practical mind to realize an economical energy source. The research field of the CFP has grown up a huge science demanding a paradigm change.

In the history of modern world after 17th century, development of a society has been entangled with the development of science and technology and the structure of this development has been a target of researches in social science. The sociology of science had been developed by sociologists who took up the problem in the 17th century England as a typical example of the mutual relation between the social development and the development of science (e.g. [Hessen 1931], [Merton 1938]). It is noticed that there are clearly seen strong influences of the sociology developed by Max Weber [Weber 1904] on their works.

It is necessary to have financial supports for the scientific activity. This phase of the science is also analyzed in the sociology of science and the history of the CFP has been closely wrapped around by competition for funds (cf. Appendix E). The competition for funds shed shadow on the development of the CFP research and recognition of the CFP by the scientific society.

In recent modern states, science is a part of national projects supported and sponsored by a nation. There appear several funding organizations in the story of the history of researches on the cold fusion phenomenon as given in Appendices E and H.

What we have to recognize about the science of the cold fusion phenomenon (CFP) is the situation of the research on the CFP at present after more than a quarter of a century after its discovery in modern science. To do so, it is helpful to learn the sociology of science which analyzes the social existence of science in general developed mainly Merton and others [Merton 1975]. It is the purpose of this paper to show that the science of the CFP has to satisfy several conditions to be recognized in the modern world in view of the sociology of science.

It may be helpful to readers of this paper to give an overview of the external and internal barriers preventing recognition of the CFP by the established scientific society.

The *external barriers* preventing recognition of the CFP as a part of the modern science are related to the following factors in this field; (1) the biased preference of deuteron systems affected by the plasma fusion (thermonuclear fusion) research, (2) neglect of unified perspective of the experimental facts obtained in protium and deuterium systems altogether, (3) lack of recognition that the CFP belongs to an interdisciplinary science between nuclear and solid-state physics and (4) neglect of complexity in formation of the situation appropriate for the CFP in the materials where the CFP occurs (CF materials).

The *internal barriers* preventing recognition of the cold fusion phenomenon are in the society of researchers and in researchers themselves. The most important one of them is the resistance to paradigm change in researchers in this field. As we show in Section 2, the CFP is a phenomenon explained by a new science in the interdisciplinary region between solid state physics and nuclear physics. To establish the science of this phenomenon, it is necessary to have a new paradigm for the experimental data in the CFP which are out of old paradigms. To accept a new paradigm, however, there are mental difficulties in scientists who have lived and therefore trapped in the old paradigms as M. Planck said in the sentence cited at the beginning of this Introduction. This is an internal barrier of researchers preventing development of the science of the CFP investigated in this paper.

1.4 Terminology of the Cold Fusion Phenomenon

It is convenient for readers to give a list of terminology characteristic to the cold fusion phenomenon which is a novel science where it is necessary to use some new concepts to describe the relations obtained by experiments..

Following is a list of technical terms characteristic in the field of the cold fusion phenomenon.

CF materials; Materials used in the CF research.
Cold fusion; [ICCF1 1990]
Cold fusion phenomena;
"Cold fusion phenomena" used by researchers at early days of investigation (e.g. [Fleischmann 1990]) seems to mean that events observed in the CF materials represent various phases of nuclear reactions between two deuterons. The main reactions had been assumed as those taken up by hot fusionists;

$$D + D \rightarrow T\ (1\ MeV) + p\ (3\ MeV), \qquad (1\text{-}1)$$

$$D + D \rightarrow {}^{3}He\ (0.l8\ MeV) + n\ (2.5\ MeV), \qquad (1\text{-}2)$$

$D + D \rightarrow {}^4He\ (0.08\ MeV) + \gamma\ (23.8\ MeV).$ (1-3)

The complex experimental results piled up in a few years after 1989 obtained in deuterium and protium systems have shown that the nature of the nuclear reactions occurring in the CF materials is not so simple.

Cold fusion phenomenon; [DOE Workshop, Kozima 1998]

According to the recognition of the complex nature of the nuclear reactions occurring in the CF materials, it has been proposed an idea to take the whole events observed there as a single entity with various faces. The entity has been named "the cold fusion phenomenon" (CFP). The "cold fusion phenomena" used by researchers in early days such as Fleischmann, Li and others correspond to the "events in the CFP" in this terminology. Many examples of the cold fusion phenomenon or the CFP are found in papers and books by H. K. [Kozima 1994, 1998, 2006, 2016a, 2017b]

It should be noticed that the *science of the cold fusion phenomenon* is a part of the science of nuclear interactions in solids which is properly called as the *solid state-nuclear physics*, *condensed matter nuclear science*."

Solid state-nuclear physics or **Condensed matter nuclear science.**

These two names represent the science or physics of events or phenomena occurring in solids induced by the interactions between nuclei and atoms. The physics of events induced by the interactions between nuclei are called as *nuclear physics* and that of events induced by the interactions between atoms and molecules are called *solid state physics* or *condensed matter physics*, as well known. The name '*cold fusion phenomenon'* is used to extract 'the events induced by nuclear reactions' from other events without nuclear reactions such as the neutron diffraction by a crystal lattice even if it is induced by the interaction of neutrons and nuclei in solids without nuclear reaction.

1.5 Outline of This Paper

In this paper, as shown in the Contents next to the Abstract, we give a brief survey of the science of the cold fusion phenomenon (the CFP) in Section 2 viewed from a phenomenological point of view using the TNCF model (the trapped neutron catalyzed fusion model), proposed at ICCF4 in 1994 and developed in these more than 20 years. The main structure of the CF research in the modern society had been determined in the first 15 years from 1989 when the first sign of the CFP was discovered, we use mainly materials obtained in this period for discussions in Section 2. Then, the sociology of the cold fusion phenomenon (CFP) is investigated in Section 3 using the framework developed by R.K. Merton [Merton 1975]. Details of materials for the discussions

developed in Sections 2 and 3 are given Appendices.

2. Discovery of the Cold Fusion Phenomenon

"*The man of science must work with method. Science is built up of facts, as a house is built of stones; but an accumulation of facts is no more a science than a heap of stones is a house. Most important of all, the man of science must exhibit foresight*." [Poincaré 1902]

2.1 Discovery of a New Field of Science in the Post-industrial Society

As explained briefly in Prologue, the social situation on the end of 20th century gave an opportunity to recollect an old phantasy dreamed by F. Paneth in 1926 [Paneth 1926, 1928]. The social environment after 60 years, however, changed drastically giving a complex drama to the new discovery explained by G. Taubes extensively but one-sidedly in his book published in 1993 [Taubes 1993].

In the course of the short history from the declaration of the discovery in March, 1989 by Fleischmann et al. [Fleischmann 1989] to the condemnation on the end of 1989 by the DOE report [DOE 1989], there appeared characteristics of the paradigm change discussed by T.S. Kuhn in his book *The Structure of Science Revolutions* [Kuhn 1962].

In this Section, we present the characteristic feature of the discovery of the CFP to give the essential problem of the science in the modern society through the history of the CFP. The chronological details of the history are replicated in Appendix D using the sentences from G. Taubes [Taubes 1993].

The discovery of the CFP was surveyed and explained phenomenologically in an author's book published in 1998 for the first time [Kozima 1998]. In this book, the author investigated whole events observed not only in deuterium systems but also in protium systems thus opened a way to the science of this complicated phenomenon characterized by nuclear reactions in CF materials in the interdisciplinary field between solid state physics and nuclear physics.

However, the history of the research on the CFP has been strongly influenced and biased by the researches on the controlled thermonuclear fusion of deuterons pursued earnestly worldwide since 1950s (cf. Appendix C). The history of the controversy between pros and cons to the CFP vividly shows the influence and is depicted briefly in Appendix D.

2.2 Science of the Cold Fusion Phenomenon

It is extremely important to realize the difference of facts and truth in daily life and in science. We want to give a short comment on this problem.

Facts and Truth

First of all, it is necessary to distinguish *truth* from *facts* especially in science. This is a plain common sense but sometimes or very often confused in minds biased by interests other than science.

The brief history of the cold fusion phenomenon depicted in Appendix D shows the reason why the communication between pros and cons has been not fruitful. The key point is that the discussion is confined in the problem if it is possible to induce the *d-d* fusion reactions in solids at near room temperature without any acceleration mechanisms. The essence of experimental facts has been cast away but details of experiments in contrast to the conventional knowledge of solid state physics and nuclear physics were taken up exaggeratedly. In this sub-section, we take up fundamental problems in the history of the CFP to clarify the essence of the solid state-nuclear physics revealed hitherto in the experimental facts of the CFP.

2.2.1 Two ways of the Approach to Unknown Problems and Experimental Facts

It is useful to contrast two useful ways of scientific approaches to investigate unknown problems.

1. Struggle in the Existing Paradigm: The first is the style used to extend the method confirmed its usefulness in a field up to the limit of the field as far as possible. The works by J. Schwinger [Schwinger 1994] and P. Hagelstein et al. [Hagelstein 2004] are typical examples in this group.

2. Look for a New Paradigm outside the Existing Paradigm: The second is contrasted to the first in leaving the existing paradigm and looking for a new one appropriated for the newly found facts. The phenomenological model proposed by us is almost only one example in this group [Kozima 1998, 2006, 1016, 2017a].

The difference in these two styles is based in the evaluation of the facts; the first considers the facts in and the second outside the existing paradigm.

Thus, the experimental facts are definitely important to investigate the CFP and tabulated in Table 2.1. They had been classified into two genres according to the relation to nuclear reactions; direct and indirect as tabulated in Table 3.2 [Kozima 2006 (Table 2.1)].

Table 2.1 System and Obtained Evidences of CFP. Mother solids, agents, experimental methods, direct and indirect evidences of the cold fusion phenomenon. Q and NT express excess heat and the nuclear transmutation, respectively. Direct evidences of nuclear reactions in CFP are Energy (ε) and position ($\boldsymbol{r}$) dependences of reaction products NT(ε, $\boldsymbol{r}$), decrease of decay constants of radiative nuclides, decrease of fission threshold energy of compound nuclei [Kozima 2006 (Table 2.1)].

Mother solids	C, Pd, Ti, Ni, KCl + LiCl, $ReBa_2Cu_3O_{7,}Na_xWO_{3,}$ KD_2PO_4, TGS, $SrCe_aY_bNB_cO_d$, Hydrogen graphite (HC_6), XLPE $(CH_2)_n$,
Agents	*n, d, p*, $^{6}_{3}$Li, $^{10}_{3}$B, $^{39}_{19}$K, $^{85}_{37}$Rb, $^{87}_{37}$Rb、(ion beam, O)
Experimental methods	Electrolysis, Gas discharge, gas contact, (ion beam irradiation)
Direct Evidences	Gamma ray spectrum γ (ε), neutron energy spectrum n(ε), Space distribution of NT products NT($\boldsymbol{r}$), decrease of decay constants, lowering of fission threshold energy
Indirect Evidences	Excess energy Q, number of neutrons N_n, amount of tritium atom N_t, helium-4 atom N_{He4}, NT (NT_D, NT_F, NT_A), X-ray spectrum X(ε)
Cumulative Observables	NT($\boldsymbol{r}$), amount of tritium atom N_t, helium-4 N_{He4},
Dissipative Observables	Excess energy Q, neutron energy spectrum n(ε), number of neutrons $N_{n,}$ Gamma ray spectrum γ (ε), X-ray spectrum X(ε),

2.2.2 Three Laws in the CFP

It has been found that there exist three empirical laws (or regularities) in experimental facts obtained in the CFP [Kozima 2012]. They are tabulated as follows;

1. The First Law; Stability Effect for Nuclear Transmutation Products
2. The Second Law; Inverse-Power Dependence of Frequency on Intensity of Excess Heat Production
3. The Third Law; Bifurcation of Intensity of Events (Neutron Emission and Excess Heat Production) in Time

These empirical laws suggest that the CFP is a phenomenon classified as complexity investigated in nonlinear dynamics in the several tens of years. The controversial problem of the reproducibility of events in the CFP should be understood by the qualitative reproducibility destined by the complexity at most.

2.2.3 Characteristics of the Cold Fusion Phenomenon (CFP)

It is easy to understand the characteristics of the CFP from the facts tabulated in Table 2.1 and the three laws found phenomenologically.

They are written down as follows with relations to the controversial reproducibility;

(a) Subtlety or difficulty in realization of the CF state (the state where occurs the cold fusion phenomenon) in CF materials. → irreproducibility
(b) Fragility of the CF state due to the products (heat and radiation) of nuclear reactions in the CFP. →qualitative reproducibility
(c) Difficulty of precision measurements of the products of the CFP. → qualitative reproducibility

Science of the Cold Fusion Phenomenon (CFP)

We may be able to consider that a first step to the science of the CFP is settled when the facts and the characteristics summarized above are explained at least qualitatively [Kozima 2006, 2016]. The theoretical investigation given by our phenomenological approach has given following *necessary conditions* for the CFP in CF materials (materials where occur nuclear reactions);

Necessary conditions for the CFP.

(1) Absorption of protium/deuterium into the material (at least in the surface regions thicker than at least about 200 A = 20 nm) with a density as high as that of the host element. It is said that the necessary average density of the hydrogen isotopes should be larger than a minimum value, given for instance by the relative composition D/Pd > 0.7 in the case of PdD_x [McKubre 1993].

(2) Formation of the superlattice composed of a sublattice of the host nuclei at the lattice points and another sublattice of protons/deuterons at the interstitial sites (at least in localized regions of the material). The self-organization might be relevant to formation of this superlattice [Kozima 2013].

(3) Existence of lattice nuclei with neutrons at evaporation levels (where the exotic nuclei are favorable) [Kozima 2014 (Sec. 2.7)].

(4) Existence of non-localized proton/deuteron wavefunctions in the material. It is probable the higher the diffusivity of protons/deuterons, the larger the extension of their wavefunctions, from experimental data in solid state physics [Kozima 2009].

(5) Realization of the super-nuclear interaction between lattice nuclei (mediated by interstitial protons/deuterons) [Kozima 2006 (Sec. 3.7.2), 2016 (Section 3.9), 2017a (Sec. 5.2.3)].

(6) Formation of the neutron energy bands by the coupled neutrons with the super-nuclear interaction [Kozima 2006, 2017a],

(7) Supply of neutrons in one (valence band) of the formed neutron bands (by excitation from lower energy levels or by supply from outside) [Kozima 1998 (Sec. 8.3), Kozima 2006].

(8) Accumulation of neutrons at boundary/surface region of the CF material to form the CF-matter [Kozima 2006 (Sec. 3.7.2.3)].
(9) Interaction of neutrons in the neutron bands and CF-matter with disordered nuclei [Kozima 2017a (Sec. 5.2)]. The neutrons in the neutron bands do not interact with lattice nuclei as its nature but interact with nuclei in such disordered sites as displaced positions in the lattice and at boundary regions. This is the cause of localization of nuclear reactions at surface/boundary regions which have observed frequently in experiments.

2.2.3 The First Stumbling Stone – The Protium System

As the controversy between pros and cons, partially reproduced in Appendix D, had been fought on the possibility of *d-d* fusion reactions in CF materials, the cold fusion reactions in protium systems, therefore, have been alienated for a long time irrespective to its importance. This alienation influenced to the biased progress of the investigation of the CFP very much. If the experimental data obtained in deuterium and protium systems are considered equivalently, the investigation of the science of the CFP may have had more profound expansion.

The experimental data on protium systems had appeared after 1989 in *Fusion Technology* (*FT*) and *Proceedings of ICCF2*. The numbers of papers on the deuterium and protium systems published in *FT* from 1991 to 1995 are shown in Table 2.1. Individual papers on the protium systems are listed in Appendix F2. G.H. Miley's comments on the Cold Fusion papers in *FT* are cited in Appendix F3 for their importance in the history of CFP research.

Table 2.1 Number of papers on deuterium (D) and protium (H) systems appeared in *Fusion Technology* (*FT*) from Vol. **16** (1989) to Vol. **27** (1995) including a special issue Vol. **26**, No. **4T-2** for ***Proc. ICCF4* (1994)** [ICCF4a] expressed as Vol. 26^{+}**.** Individual papers (titles, authors) on protium systems are given in Appendix F2.

FT Vol.	16	17	18	19	20	21	22	23	24	25	26	26^{+}	27	*Proc. ICCF* *
D-system	23	15	27	20	15	11	15	8	13	9	6	65	5	83
H-system	0	1	1	0	0	0	1	2	2	0	2	9	0	29

*****_Proceedings of ICCF4_ in 4 volumes [ICCF4b] is published simultaneously with the *Fusion Technology* **26, 4T-2** (1994) including all papers presented at the Conference. The differences of numbers in the columns Vol. 26^{+} and *Proc. ICCF4** show that papers on H-systems are mainly published in the latter.

After ICCF3 (1993) where four papers on the CFP in protium systems were presented, there appeared gradually papers showing the CFP with protium systems. However, many researchers in this field had adhered to deuterium systems. And therefore, opponents against the CFP concentrated their attack to the experimental data and theoretical works on the deuterium systems neglecting those on protium systems. The situation has been described in Sec. 3.2.1.

As explained in Secs, 3.2.1 and 3.2.2, it is wastes of time and energy to struggle with a phantasy without roots. Taking up only a part of events in the CFP is not a way to the science of the phenomenon. It is necessary to have a common ground to look for scientific explanation of the experimental data as a whole obtained in the CFP: Truth is grounded in facts.

2.2.4 The Second Stumbling Stone – The Reproducibility

As described in Section 2.2.2, the experimental facts suggested that the CFP is a phenomenon to be classified in complexity, studied extensively in nonlinear dynamics.

It has been a controversial problem, however, if the experimental results in the CFP are reproducible or not. It is a nonsense question if we notice that there are very many instances where the reproducibility has its meaning only in a statistical sense in the events in quantum physics containing nuclear physics. A simple example of the qualitative reproducibility is the alpha decay of a radioactive nuclide, e.g. radium $^{226}_{88}$Ra to $^{222}_{86}$Rn, we have taken up often in our papers and books (e.g. [Kozima 2006 (Sec. 2.14)]). We know a statistical number of decaying nuclei but not which ones will decay next.

Thus, the controversial problem of the reproducibility of events in the CFP is explained as a natural result of complexity in the process of formation of CF materials in the dynamical conditions used in the experiments [Kozima 2006, 2010, 2012, 2016 (Section 3.8)].

3. The Sociology of the Cold Fusion Research

"*The sociology of knowledge came into being with the signal hypothesis that even truths were to be held socially accountable, were to be related to the historical society in which they emerged.*" [Merton 1975 (p. 11)]

As we have given a brief survey on the history of researches on the CFP in Section 2, its possible influences and the novel features on the modern world inevitably invited

confusion not only in science but also in science policy. After almost 30 years from the discovery of a part of the CFP by Fleischmann et al. [Fleischmann 1989], the situation around the CFP has not changed much. This situation is asking us sociological analyses on it.

We give here an essay to investigate the history of the CFP using the concepts developed by sociologists which are summarized in Appendix A.

3.1 Sociology of the Cold Fusion Phenomenon

The Sociology of the Cold Fusion Research (the Research on the Cold Fusion Phenomenon) is a part of the Sociology of Science investigated for about a century by sociologists especially by a group led by R.K. Merton [Merton 1975] (cf. Appendix A).

The general discussion of the sociology of science will give a firm standpoint to analyze the development of the CF research in this society and give a hint to integrate it into modern science as an inevitable part of it. We investigate the sociology of the CFP in this section using the concepts developed by R.K. Merton et al. summarized in Appendix A.

3.1.1 The Sociology of Knowledge in 21st Century

The sentences cited in Appendix A1 from Merton's book are mainly for social scientists but applicable also to natural scientists. Especially, the following sentence from the Merton's paper on the sociology of knowledge is suggestive for us [Merton 1975 (p. 11)].

"The 'Copernican revolution' in this area of inquiry consisted in the hypothesis that not only error or illusion or unauthenticated belief but also the discovery of truth was socially (historically) conditioned. - - - The sociology of knowledge came into being with the signal hypothesis that even truths were to be held socially accountable, were to be related to the historical society in which they emerged." [Merton 1975 (p. 11)]

We have to notice the social situation in 21st century where genuine reality has been overwhelmed by virtual reality in society as especially exhibited in political world. The development of information technology (IT) e.g. such as social network service (SNS), has changed human relations in the society. The Merton's sentence cited above should be considered seriously in consideration of scientific truth.

3.1.2 The Sociology of Scientific Knowledge in 21st Century,

The conglutination of technology and science has largely advanced in 20th century and appearance of huge industries has changed the character of the science in modern

society. It is already noticed by R.K. Merton that the relation of science and its environment changes when the society changes its character (cf. Appendix A2 [Merton 1975 (p. 176)]). Details of the interaction between the cold fusion research and the controlled nuclear fusion casting a shadow on the funding problem have been given in Subsection 3.2 and Appendix D.

The sentences cited in Appendix A2 from Merton's book depict a traditional concept of science extracted from history of science since 16th century until the beginning of 20th which should be considered obsolete now. The close connection between science and military technique, however, had been noticed early in 1935 [Merton 1975 (Section 9)]. Several sentences are cited below from Merton's paper.

"The foci of scientific interest are determined by social forces as well as by the immanent development of science. We must therefore examine extrascientific influences in order to comprehend more fully the reasons why scientists have applied themselves to one field of investigation rather than another. With the view of tracing such a connection between science and society, I shall indicate the ways in which military exigencies have encouraged the growth of one branch of science, especially in seventeenth century England." [Merton 1975 (p. 204)]

3.1.3 The Normative Structure of Science,

According to the strong connection of science and society and to the huge effects of science on society, science has become an important brick of modern society. Following sentence by Merton explains the situation compactly.

"Incipient and actual attacks upon the integrity of science have led scientists to recognize their dependence on particular types of social structure. Manifestos and pronouncements by associations of scientists are devoted to the relations of science and society. An institution under attack must reexamine its foundations, restate its objectives, seek out its rationale. Crisis invites self-appraisal. Now that they have been confronted with challenges to their way of life, scientists have been jarred into a state of acute self-consciousness: consciousness of self as an integral element of society with corresponding obligations and interests.[1]

1. Since this was written in 1942, it is evident that the explosion at Hiroshima has jarred many more scientists into an awareness of the social consequences of their work." [Merton 1975 (pp. 267 – 268)]

Several explanations on the normative structure of science by Merton are cited in Appendix A3.

3.1.4 The Reward System of Science in 21st Century,

The change of structure of science has given a large alteration in the reward system of science. Especially, the cold fusion phenomenon has not been established its existence in society and therefore many researchers in this field could not find out stable positions for their research. It is necessary to establish the science of the cold fusion phenomenon first to consider the reward system of this field comparable to that in the established fields of science.

Some considerations on the reward system of science discussed by social scientists are given in Appendix A4.

3.1.5 The Process of Evaluation in Science in Modern Industrial Society.

The process of evaluation of works on the CFP is in similar situation to the problem of the reward system due to the unestablished situation of this research field. Several sentences on the process of evaluation in science by Merton are cited in Appendix A5.

There are a few periodicals accepting papers on the cold fusion phenomenon at present as surveyed in Appendix F.

3.2 Funding Organizations and Their Influence on the Research

There have been very many examples showing shortcomings of the Big Science phenomenon in modern society. The episodes described in books by J.R. Huizenga [Huizenga 1992] and G. Taubes [Taubes 1993] had shown typical phases of the shortcomings with many unscientific biased conclusions discarding pearls of truth in the facts.

In relation to the problems considered in Subsections 3.1.4 and 3.1.5, the funding systems in modern technological world are one of fundamentally important organizations in a society. A feature of the competition for funds has appeared in the history of the CFP as described in Appendix E. We cite several sentences from books by G. Taubes, J.R. Huizenga and D.R.O. Morrison below to know the facts. More examples are shown in Appendices E and H.

3.2.1 Taubes describes the background of the competition between U-o-U and BYU

Martin Fleischmann and B. Stanley Pons in the University of Utah (U-o-U) vs. Steven Jones of Brigham Young University

“Once Stan Pons submitted his proposal to his benefactors at the Office, of Naval Research, the cold fusion affair took on an aura of inevitability. Although ONR had a reputation for funding speculative research projects, either Pons or Robert Nowak, his

funding officer, decided that ONR was not the right place for cold fusion. Pons told Hugo Rossi that he feared the Department of Defense, of which ONR was a part, might classify cold fusion. They might realize the potential military uses of an invention that, if it wasn't a hydrogen bomb itself, would still produce tritium, a necessary and valuable component of hydrogen bombs.

Since Pons preferred to think of cold fusion as an energy source, not a weapon, he sent the proposal to his friend Jerry Smith, a funding agent in the Department of Energy's physical chemistry program. At one time Smith had been program manager for Pons at ONR, and his name appears as a coauthor on several of Pons's journal articles. Smith, too, felt that cold fusion was inappropriate for his office and suggested that Pons submit his proposal to the Office of Advanced Energy Projects at DOE run by an administrator named Ryszard Gajewski (pronounced Richard Guy-EV-ski).” [Taubes 1993 (Chapter 2, The Competition, p. 19)]

“During his tenure Gajewski had managed to support two projects for six years or longer. The first was an X-ray laser project for hot fusion, which was being pursued by a Princeton physicist.[2] The second was known as muon-catalyzed fusion, the forerunner of what has since been called cold fusion. Muon-catalyzed fusion was one of Gajewski's visions. He equated it to his own background. "Like an immigrant's child Gajewski once wrote of muon-catalyzed fusion, "in order to succeed in a big way we must prove that we have something clearly superior to offer, something the society simply cannot ignore.

The point man for this program was Steven Jones of Brigham Young University. After the announcement on March 23rd, when the press discovered that Jones had also been studying cold fusion and were trying to establish the nature of the relationship between Pons, Fleischmann, and Jones, Gajewski would tell reporters that if he had to choose three people to trust in the world, Jones would be one of the three. Left unsaid, of course, was that neither of the other two would be Pons or Fleischman.” [Taubes 1993 (p. 21)]

3.2.2 J.R. Huizenga and D.R.O. Morrison also described the situation;

“The First Annual Conference on Cold Fusion (ICCF1), sponsored by the National Cold Fusion Institute, was held in the University Park Hotel, a few yards away from the NCFI, on March 28 – 31, 1990.” [Huizenga 1992 (p. 170)]

The National Cold Fusion Institute was established in the University of Utah in March, 1989 by the State of Utah expecting a financial support from the US Government.

“At present the greatest part of the funding for Cold Fusion comes from Japan; IMRA (supported basically by Toyota) has set up labs in France and Japan: and MITI (Ministry of International Trade and Industry, Japan) is starting to devote $30 million over four years. The question is, why?” [Morrison II (No. 9, General Impressions on ICCF4)]

3.2.3 Distortion of science caused by the funding system

To get financial supports from funding organizations, researchers emphasize the possible applications of the newly found phenomenon rather than engage in scientific researches of the truth behind the facts. In this process, they select useful facts discarding facts seemingly unuseful for the application in their minds.

The CFP in protium systems had been the typical example discarded for a long period due to its irrelevance to the *d-d* reactions supposed to be valuable for an energy source without much trouble of supply and hazardous waste.

3.3 Paradigm Revolution

It is difficult to leave a world where we are accustomed and living easily without much care about environmental affairs. However, we have to reconstruct our world to accept new facts contradicting with the established frame of the old world. When it occurs in scientific world, the new world is called a new paradigm by T. Kuhn [Kuhn 1962]. The controversy between pros and cons of the CFP depicted in Appendix D using their sentences is seen as a battle for their paradigms; however their paradigms are very similar confined to the *d –d* fusion reactions to explain the new facts.

It is necessary to have a new paradigm to give an unified explanation of various facts observed in deuterium and protium systems as introduced in Section 2. We give a brief explanation of the situation explained above.

3.3.1 Neglect of truth in new facts by biased view persistent to old prejudice.

Corresponding to the biased view in the researchers of the CFP, scientists in other relevant research fields, such as nuclear physics and solid-state physics, criticized the efforts by the CF researchers missing in this case the facts showing novel features of solid-state nuclear physics both in protium and deuterium systems too eager to criticize possibilities of the *d-d* fusion reactions in solids at near room temperature.

3.3.2 Logics of Opponents to deny the Facts of the CFP

We can trace logics of opponents to deny the facts of the CFP only criticizing the

experimental and theoretical demands of CF researchers to show possibilities of the *d-d* fusion reactions.

3.3.2a J.R. Huizenga [Huizenga 1992]

J.R. Huizenga was a co-chairman of the U.S. Department of Energy's Cold Fusion Panel in 1989. After the publication of "DOE Report 1989" (*A Report of the Energy Research Advisory Board to the United States Department of Energy*, DOE/S-0073 DE90 005611 (1989)) [DOE 1989], he published his book on the cold fusion using his knowledge on nuclear physics and materials in the "Report" [Huizenga 1992]. Naturally, he had no motivation to find out truth behind the experimental facts, mixed naturally with correct and incorrect ones.

"The process of fusion of two deuterium atoms was first studied by Ernest Rutherford and his colleagues at the Cavendish Laboratory in Cambridge (*Nature*, **133**, p. 413, 1934; *Proc. Roy. Soc.* **A148**, p. 623, 1934). During the ensuing half century, nuclear fusion of deuterium has been studied intensively and it is now a relatively well understood process. If fusion between deuterium atoms were indeed occurring at room temperature, there is essentially no doubt what the products would be. They would be the same products that are observed for reactions between two low-energy deuterium nuclei, where fusion is known to proceed in three channels:

D + D →[4He]* →

^{3}He (0.82 MeV) + n (2.45 MeV), (1a)

T (1.01 MeV) + p (3.02 MeV), (1b)

^{4}He (0.08 MeV) + gamma ray (23.77 MeV) (1c)"

[Huizenga 1992 (p. 6)].

"If the energy burst were truly nuclear in origin, equivalent amounts of fusion products must have been released. Without this confirming evidence of commensurate yields of fusion products, Fleischmann and Pons' claim did not convince most scientists that a nuclear process had occurred." [Huizenga 1992 (p. 70)]

"These researchers all reported different amounts of excess heat and different criteria for success. In attempts to produce excess heat, Bockris emphasized that there was "considerable ^reproducibility" while Pons stated that he could now "... reproduce it more than 90% of the time" (Salt Lake Tribune, May 10, 1989). Although these two advocates of cold fusion disagreed sharply on the question of reproducibility, they, along with others, claimed success in producing excess heat." [Huizenga 1992 (p. 71)]

“Fleischmann and Pons' gamble to go public with their announcement of watts of 'excess power' from nuclear fusion at room temperature, before they had any solid evidence of fusion products, is the scientific fiasco of the century. The chasm between Fleischmann and Pons' claim of 'excess heat' and the upper limit on the intensities of the associated fusion products continues to be many orders of magnitude! Room temperature nuclear fusion without commensurate amounts of fusion products is a delusion and qualifies as pathological science defined as ‘the science of things that aren't so’.” [Huizenga 1992 (p. 214)]

3.3.2b D.R.O. Morrison [Morrison I, II]

D.R.O. Morrison has enthusiastically pursued the truth behind experimental facts observed by CF researchers and by critics from his point of view confined in the framework restricted only in *d-d* fusion reactions. His publications on the CFP have been from 1989 to 2000. He attended all ICCF (the International Conferences on the Cold Fusion) from the first (1990) to 8th (2000) held almost annually; the first was held on 28 to 31, March 1990 in University of Utah, USA and the 8th on 21 to 26, May 2000 in Lerici (La Spezia), Italy.

Morrison has attacked the experimental data inconsistent with the *d-d* fusion reactions that have been observed in free space and fully investigated in nuclear physics. We have heard every time his critical questions at ICCFs “That is in contradiction with the common sense of the nuclear physics.”

Some examples of his criticism are cited below from his *Cold Fusion News* No. 1 (1989) – 10 (1990) cited as [Morrison I] and *Cod Fusion Updates* No. 1 (1990) – No. 13 (2000) cited as [Morrison II].

“Finally society must make a judgement on this subject that has excited such great interest and raised such wonderful hopes. Although most, though not all, workers in the field realise that cold fusion will never be of any practical use for power production, this is still not the popular perception of it. Most people still hope that maybe something will come of it. There seems to be a tendency amongst some to let the bad news leak out slowly. This is often good politics and PR, but not all scientists feel this way - they want to avoid people getting into false positions because of lack of knowledge of the facts.

There is a second question which is of purely academic interest - does there exist cold fusion at some very low level (a billionth or a trillionth or a billion-billionth of a Watt). Clearly the Fleischmann and Pons level is excluded by the data, but some hope it might

occur at the BYU level, but again there are good experiments which find no counts at much lower levels. So one cannot avoid asking the difficult question of whether all the positive results are mistaken. Scientists do not want this to be correct, but can one exclude it?" [Morrison I (No. 14, Conclusions)]

"A major topic is the experiment of Mike Salamon et al. who did not observe any neutrons or gammas when positioned below four of Pons's cells. They have new strong evidence against any fusion product emission at a time when Prof. Pons said one of his cells gave heat. This was published by Nature during the conference." [Morrison I [No. 22 (Summary)]

"From my studies of Pathological Science, it is possible to make some guesses. - - -
Those groups that have found positive results will not suddenly find errors and withdraw their papers. Rather they will publish work enroute but then will stop publishing. They will say they have never found anything wrong with their experiments." [Morrison I (No. 23. What is the Future)]

"Scientists are educated to study and believe experimental results. And when young they do. Their culture makes them very trusting and there results an exceptionally good working atmosphere. However magicians such as Randi say that scientists, especially physicists, are the easiest people to deceive. This is because they virtually never encounter fraud in their work and rarely hear lies.
The consequence is that when there are good grounds for suspecting fraud, scientists generally do not know how to deal with it." [Morrison II (No. 1. Problems of Dealing with Fraud)]
"The major problem of Cold Fusion - the disagreement of the amount of heat claimed and the corresponding expected number of nuclear products - still exists. Surveys still indicate other major problems, particularly reproducibility." [Morrison II (No. 5. Summary of Report on ICCF2)]

"These other claims included several groups saying that they observed excess heat with normal water, i.e. light hydrogen - this is in contradiction with Fleischmann and Pons and others who said it happens only with heavy hydrogen (deuterium) and the proof that it is nuclear fusion is that it is NOT observed with light hydrogen." [Morrison II (No. 7. Summary for ICCF3 Report)]

D.R.O. Morrison finally became more tolerant to variety of approaches to the science of the CFP as citing many theoretical works in his review on the ICCF8 but could not recognize the truth hidden behind complex, sometimes contradicting experimental data; one example of the former and his comment showing the latter are cited below from the final *Cold Fusion Updates* **No. 13**, 2000 published after ICCF8.

"12. H. Kozima (abs. 044, 045, 046) Trapped Neutron Catalyzed Fusion, TNCF model. Energy band of neutrons interacts coherently with lattice nuclei.

e.g.

n + $_{46}$Pd -----> $_{13}$Al + $_{33}$As or -----> $_{26}$Fe + $_{20}$Ca." [Morrison II (No. 13 Appendix 2, Theories at ICCF-8)]

<In this citation, Morrison has shown his correct understanding of the TNCF model as his explanation of the lack of radiation in the nuclear reaction as "*Energy band of neutrons interacts coherently with lattice nuclei.*"> (Italicized at citation).

"11. CONCLUSIONS

I have often looked at experiments which gave results that appeared to violate the laws of Nature which had been established by previous work. Later these experiments turned out to be false, but I have often found it very difficult to see just where the error was. But the fact that I had not detected the flaw, did not mean that the experiment was correct and that the laws of Nature had been violated.

Rather I feel the same as being at a circus watching a magician. Normally he and I know that the laws of nature are being obeyed but there is a trick which is hard to spot. At trick one, I may spot the trick and am happy that there is no problem with the laws of Nature - similarly with trick number two. But suppose at trick three, I do not see how the magic is performed. The magician may say "I won, I tricked you" and it is left unsaid that the laws of nature have not been violated. But suppose the magician says "You did not see anything wrong with my demonstration, therefore it is true. See, I have supernatural powers. The old laws of Nature have been replaced by new laws". And if I protest, I am told that I have a closed mind, am an establishment figure, and do not face up to the happening performed in front of me. But almost all magicians admit that it is all trickery and the laws of Nature are not threatened.

So if someone comes along and says, "Look - excess heat - do you see anything wrong?", then I feel as if I am at the circus, and although I do not immediately see anything wrong, I am reluctant to give up well-established laws of Nature unless the proof is very strong. Here reports on cold fusion happenings are described, especially in the summary talks by True Believers in cold fusion in their words, and then some clues

as to possible explanations are offered. How many Elvis sightings constitute a proof?" [Morrison II (No. 13. Conclusions)].

3.3.2c G. Taubes [Taubes 1993]

G. Taubes wrote his book on the episode of cold fusion using his interviews with over 260 scientists, administrators, and journalists within the limits of his knowledge on physics. He had no intension to find out the truth behind the experimental facts and therefore just denied facts (mixed with correct and incorrect ones) obtained at that time comparing with his knowledge of nuclear reactions in nuclear physics.

"Nuclear reactions generate nuclear radiation. That is the nature of the beast. Even without calculating exactly how much neutron radiation should have been emitted by four watts of fusion power, one indication that Pons and Fleischmann had observed too little was their reasonably robust appearance.[4] The radiation emitted from this level of power generation should have been sufficiently malign for its effects to have been noticeable. In fact, the radiation would have killed the two chemists, not to mention seriously impaired the health of the students working nearby. But it hadn't. So where were the neutrons?

[4] Fleischmann, in fact, admitted at the press conference that they had observed only a billionth as much helium, tritium, and neutrons as they expected, but this hadn't appeared in the press reports." [Taubes 1993 (pp. 117 and 441)]

"He pointed out that the tritium was incompatible with the neutrons, which were incompatible with the heat, and suggested to a panel of what The Deseret News was now calling the fusion fraternity that one or several of these results had to be wrong. Would the people with the wrong results please raise their hands? Kellogg asked. He was ignored." [Taubes 1993（p. 406）]

"Within six months of the announcement of cold fusion, its public life had deteriorated into a dismaying struggle against reality in which the believers explained the insipid state of their science with all manner of causes, none of which was as simple as the reality itself. Cold fusion—as defined by Stanley Pons and Martin Fleischmann, or Steve Jones, or as modified by John Bockris or Edmund Storms and Carol Talcott, or Bob Huggins-Stanford, or whomever—did not exist. It never had. There was at least as much empirical evidence, if not more, to support the existence of any number of pseudoscientific phenomena, from flying saucers to astrology." [Taubes 1993 (Epilogue pp. 425 – 426)]

“Of all the arguments spun forth in defense of cold fusion, the most often heard was that there must be something to it, otherwise the mainstream scientific community would not have responded so vehemently to the announcement of its discovery. What the champions of cold fusion never seemed to realize, however, or were incapable of acknowledging, was that the vehemence was aimed not at the science of cold fusion but at the method. Positive results in cold fusion were inevitably characterized by sloppy and amateurish experimental techniques. If these experiments, all hopelessly flawed, were given the credibility for which the proponents of cold fusion argued, then science itself would become an empty and meaningless endeavor. Once bad science was accepted as good enough, it could be used to prove the existence of anything, whether it existed or not.” [Taubes 1993 (Epilogue p. 426)]

“What cold fusion had proven, nonetheless, was that the nonexistence of a phenomenon is by no means a fatal impediment to continued research. As long as financial support could be found, the research would continue. And that support might always be found so long as the researchers could obtain positive results. In fact, the few researchers still working in the field would have little incentive to acknowledge negative results as valid, because such recognition would only cut off their funds. It promised to be an endless loop.” [Taubes 1993 (Epilogue p. 426)]

3.4 Miscellaneous

In this section, we give miscellaneous problems related to the sociology of the cold fusion phenomenon.

3.4.1 Conferences where presented papers on the CFP (cf. Appendix G)

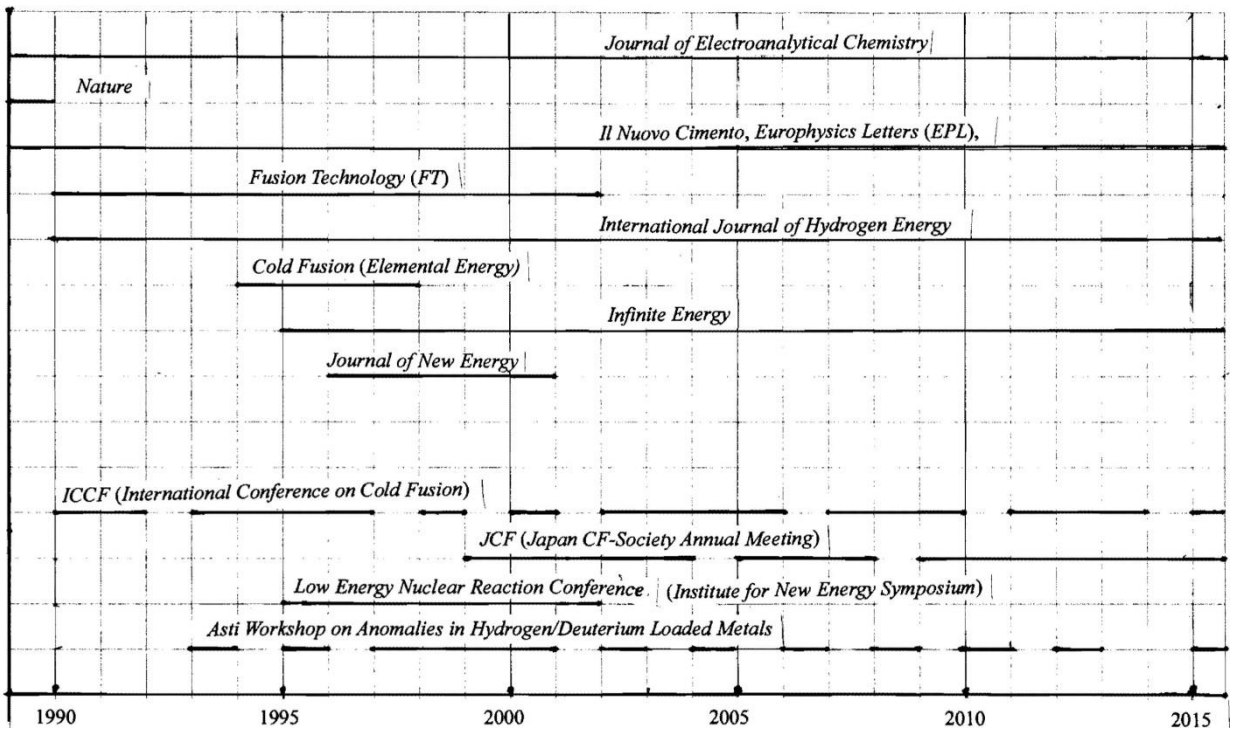

Fig. 4.1 Main journals and conferences where published and presented works on the CFP since 1989 to 2016 (cf. Appendix F).

3.4.2 Publication of Works (cf. Appendix F)

Journals which treated the CFP did not last long except a few cases (which are published by organizations) due to the lack of funds, internal competitions within researchers in this field and also by the aging of publishers (cf. Fig. 4.1 and Appendix F).

4. Conclusion

"*Thus science develops an autonomous corpus of investigation which has its origin in strictly scientific, not utilitarian, considerations. It is these developments (which probably constitute the greater part of science) arising from the relative autonomy of scientific work that seem to have little or no connection with social forces.*" [Merton 1975 (p. 209)]

The science is a part of social activity and inevitably influenced by the social situation at the time.

In the industrial and capitalistic world at present, the science, especially the big science, is governed by the logic of capitalism which is wholly independent of scientific spirit caused by curiosity and based on facts.

The foundation of the science in a society is closely related to the atmosphere to evaluate reality above all. This is the factor taken up by Merton in *The Sociology of Knowledge* as a premise of *the Sociology of Science* [Merton 1975]. If the atmosphere to evaluate knowledge is lost, it is clear that the science loses its foundation and will wither and die. How changes the atmosphere of a society? It should be a fundamental problem of the sociology of science. We might be in the final stage of a society in which science has prospered for more than 400 years.

It seems that the most important fundamental cause of the confusion in the research of the CFP lasting more than 25 years is the persistence or adherence to the *d-d* fusion reactions for the nuclear reactions in CF materials. In the persistence to the *d-d* reactions, there certainly is expectation of financial merits obtained by the application of the phenomenon rather than scientific clarification of the mechanism of the CFP. This biased intention in the scientific research distorted the research work itself and also critics on the work lasting very long without any fruits.

However, as R.K. Merton said in the sentence cited at the top of this Section, the science of the cold fusion phenomenon has been developing steadily revealing a new feature of physics of neutrons in CF materials as a part of solid state-nuclear physics (e.g. [Kozima 2006, 2016, 2017a]).

Application of this phenomenon will be considered apparently when the whole image of the cold fusion phenomenon is brought to light. We are able to expect at least applications of following effects confirmed in the CFP occurring in boundary regions of CF materials; nuclear transmutations of elements, acceleration of decays of radioactive nuclei, and production of large excess energy liberated in nuclear reactions in CF materials.

Epilogue – At the Dusk of a Civilization

"Truth. It's grounded in Facts." – New York Times (April 1, 2017).

It is considered that there had been two periods of fundamental change in the history of science hitherto as mentioned by B. Barnes;

" - - - drawing attention to the two most important periods of fundamental change in the history of science – *the cultural revolution of the sixteenth and seventeenth centuries*,

and *the social reorganization of the nineteenth*." [Barnes 1972 (Introduction, p. 11)] (Italicized at citation).

We have to add the third period to the two noticed above; *the social revolution of the twenty first century*. Trend of the world seems inclining toward virtual reality from true or genuine reality.

The scientific discovery at the far limits of human knowledge such as uncertainty principle ([Heisenberg 1927]), incompleteness theorems ([Goedel 1931]) and furthermore the complexity (e.g. [Nikolis 1989]) might be influencing the trend in deep bottom of our culture.

The personal inability to interfere the movements of world affairs such as the development of powerful warfare, the global warming, and the population explosion may be causing apathy of people to everything despite of, or rather due to the developments of information technology and biotechnology. As early as the year 1941, E. Fromm noticed the apathy toward reality due to inability to interfere the flow of social affairs [Fromm 1941].

The tendency seems to be prevailing worldwide in the beginning of 21st century. The social affairs appeared in recent years on the end of 2010s may be a signal of the apathy in psychological sphere of human being all over the world. The science is a part of human activities belonging to the Reason. In the three major characteristics of human beings, Reason, Feeling and Intention, the Reason may be the last obtained or grown up in our brain. This means the Reason is most insensitive to the change of environment. The changes of social atmosphere appeared in the Feeling and the Intention worldwide in recent years may erode the totality of human beings resulting in such a tragedy we suffered in 1930s in the previous century.

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Appendices

Appendix A – Sociology of Science

The Sociology of Science developed by R.K. Merton and others is a part of the Sociology of Knowledge. The works on the Sociology of Science are divided accordingly in five sections as follows [Merton 1973 (Introduction by N.W. Storer)]; (1) The Sociology of Knowledge, (2) The Sociology of Scientific Knowledge, (3) The Normative Structure of Science, (4) The Reward System of Science, and (5) The Process of Evaluation in Science. The each division includes works on science especially in 17th century England and in modern Europe and America and exhibit requisite for a science to exist in the society. These divisions show necessary conditions for the CFP to be a branch of science in the modern society. We therefore summarize investigations given in these works in this Appendix A.

"It was at this same time that Merton wrote his dissertation, *Science, Technology, and Society in Seventeenth-Century England* (begun in 1933 and completed two years later)." [Merton 1975 (Storer, p. xv)]

A1 Sociology of Knowledge

There are brief characterizations of the sociology of knowledge in the Prefatory Note to Chapter 1.

"- - - social scientists have a normative obligation to assert their scholarly values against the short-range and self-interested objectives often found in research requests coming from policy makers. This suggests that the current discovery of such problems and

perspectives in "the New Sociology" may rather be a reaffirmation under social conditions now more propitious to such views than before; in fact, the “cryptomnesia” (see the last paper in section 4 of this volume) suffered by successive generations of social scientists on this subject is itself a specific problem for the sociology of knowledge.” [Merton 1975 (Storer, p. 6)]

This sentence is suggestive also to natural scientists at present.

“A program for relating philosophical conceptions of the sources of knowledge in society to the empirical investigation of specified problems is sketched out in the explicit "paradigm" laid out early in the essay.” [Merton 1975 (Storer, p. 4)]

R.K. Merton formulates the paradigm for the sociology of knowledge in his paper published in 1945 just after the WWII.

“**Paradigm for the Sociology of Knowledge** [Merton 1975 (pp. 12 – 13)]

1. **Where is the existential basis of mental productions located?**

a. social bases: social position, class, generation, occupational role, mode of production, group structures (university, bureaucracy, academies, sects, political parties), "historical situation," interests, society, ethnic affiliation, social mobility, power structure, social processes (competition, conflict, and so on).

b. cultural bases: values, ethos, climate of opinion, Volksgeist, Zeitgeist, type of culture, culture mentality, Weltanschauungen, and so on.

2. **What mental productions are being sociologically analyzed?**

a. spheres of: moral beliefs, ideologies, ideas, the categories of thought, philosophy, religious beliefs, social norms, positive science, technology, and so on.

b. which aspects are analyzed: their selection (foci of attention), level of abstraction, presuppositions (what is taken as data and what as problematical), conceptual content, models of verification, objectives of intellectual activity, and so on.

3. **How are mental productions related to the existential basis?**

a. causal or functional relations: determination, cause, correspondence, necessary condition, conditioning, functional interdependence, interaction, dependence, and so on.

b. symbolic or organismic or meaningful relations: consistency, harmony, coherence, unity, congruence, compatibility (and antonyms); expression, realization, symbolic expression, Strukturzusammenhang, structural identities, inner connection, stylistic analogies, logicomeaningful integration, identity of meaning, and so on.

c. ambiguous terms to designate relations: correspondence, reflection, bound up with, in close connection with, and so on.

4. **Why related? Manifest and latent functions imputed to these existentially**

conditioned mental productions.

a. to maintain power, promote stability, orientation, exploitation, obscure actual social relationships, provide motivation, canalize behavior, divert criticism, deflect hostility, provide reassurance, control nature, coordinate social relationships, and so on.

5. **When do the imputed relations of the existential base and knowledge obtain?**

a. historicist theories (confined to particular societies or cultures).

b, general analytical theories." (Boldfaces added at citation)

A2 The Sociology of Scientific Knowledge

Scientific knowledge is always a part of knowledge in a society. The sociology of scientific knowledge follows naturally the sociology of knowledge [Merton 1975].

"--- how science comes to develop in the first place. This is followed by the correlative, more specific question: Once science comes culturally and institutionally established, what affects the rate and directions of its development?" (p. 139)

"--- the short-range ebb and flow of scientific attention can be attributed largely to causes internal to science (the sources of more long-range shifts are taken up later in the monograph, with the conclusion that they are much more affected by extrascientific changes). (p. 140)

"--- the autonomy-oriented character of scientific knowledge in its demonstration that aggregates of scientists will frequently pick up a topic because of its applied value and then transform it into a "pure" scientific problem that leads off in directions having less and less relevance to the originating occasion." (p. 141)

In the preface to the reprinted paper, *Science, Technology and Society in 17th Century England*, published in 1970, R.K. Merton noticed the historical characteristic of the relation between science and its environment as follows;

"It is now quite evident to me and I hope will become evident to its readers that this inquiry into the interdependence of science and other institutional spheres in seventeenth-century England neither adopts a factor theory nor supposes that the character of interchanges between institutional spheres that occurred in that period is much the same in other cultures and other times. Rather, it states in so many words that the nature and extent of these interchanges differ in various societies, depending on the state of their science and of their institutional systems of economy, politics, religion, military, and so on. This should not come as a strange idea. After all, the relations

between science, economy, and government in England of the seventeenth century, when modern science and its technological offshoots were only in their beginning, differ palpably from their relations in the twentieth-century United States or Soviet Union, where science has long been institutionalized, where scientific research requires vast support, and where it has acquired new magnitudes of consequence for technologies of production and destruction. The recent highly publicized discovery of the industrial-military-scientific complex only brings to our notice tendencies toward the interdependence of science and other social institutions that have, to a degree, been present all along. That, at least, is the import of the chapters in this monograph that examine the relations of science and technology with economic development and military technique." [Merton 1975 (p. 176)]

A3 The Normative Structure of Science

The ethos of science is difficult problem in the conflict of values in modern society. The following sentence written by R.K. Merton in 1942 explains the difficulty briefly.
"Science, like any other activity involving social collaboration, is subject to shifting fortunes. Difficult as the notion may appear to those reared in a culture that grants science a prominent if not a commanding place in the scheme of things, it is evident that science is not immune from attack, restraint, and repression. Writing a little while ago, Veblen could observe that the faith of western culture in science was unbounded, unquestioned, unrivaled. The revolt from science which then appeared so improbable as to concern only the timid academician who would ponder all contingencies, however remote, has now been forced upon the attention of scientist and layman alike. Local contagions of anti-intellectualism threaten to become epidemic." [Merton 1975 (p. 268)]

"The ethos of science is that affectively toned complex of values and norms which is held to be binding on the man of science.[2] The norms are expressed in the form of prescriptions, proscriptions, preferences, and permissions. They are legitimatized in terms of institutional values. These imperatives, transmitted by precept and example and reenforced by sanctions are in varying degrees internalized by the scientist, thus fashioning his scientific conscience or, if one prefers the latter-day phrase, his superego. Although the ethos of science has not been codified,[3] it can be inferred from the moral consensus of scientists as expressed in use and wont, in countless writings on the scientific spirit and in moral indignation directed toward contraventions of the ethos." [Merton 1975 (pp. 268 – 269)]

“ --- “the sentiments embodied in the ethos of science – characterized by such terms as intellectual honesty, integrity, organized skepticism, disinterestedness, impersonality.” (p. 225)

There are, however, some instances that betrayed the normative ethics of science as illustrated by historian in science (e.g. [Broad 1982])

“The antipathy toward the technological products is projected toward science itself.” [Merton 1975 (Storer, p. 226)]
“Four sets of institutional imperatives – **universalism, communism, disinterestedness, organized skepticism** – are taken to comprise the ethos of modern science.” [Merton 1975 (p. 270)]

We give short explanations for these key concepts below [Merton 1975];

A3-1 Universalism

“Universalism finds immediate expression in the canon that truth-claims, whatever their source, are to be subjected to *preestablished impersonal criteria*: consonant with observation and with previously confirmed knowledge.” (p. 270)

A3-2 Communism

“’Communism,’ in the nontechnical and extended sense of common ownership of goods, is a second integral element of the scientific ethos.” (p. 273)

A3-3 Disinterestedness

“”Science, as is the case with the professions in general, includes disinterestedness as a basic institutional element.” (p. 275)
“It is rather a distinctive pattern of institutional control of a wide range of motives which characterizes the behavior of scientists.” (p. 276)

A3-4 Organized Skepticism

“ --- organized skepticism is variously interrelated with the other elements of the scientific ethos. It is both a methodological and an institutional mandate.” (p. 277)
“Conflict becomes accentuated whenever science extends its research to new areas toward which there are institutionalized attitudes or whenever other institutions extend their control over science.” (p. 278)

“- - - these conflicts (conflicts over priority) are largely a consequence of the institutional norms of science itself comes closer, I think, to the truth. For, as I shall suggest, it is these norms that exert pressure upon scientists to assert their claims, and

this goes far toward explaining the seeming paradox that even those meek and unaggressive men, ordinarily slow to press their own claims in other spheres of life, will often do so in their scientific work." (p. 293)

"Recognition of what one has accomplished is thus largely a motive derived from institutional emphases. Recognition for originality becomes socially validated testimony that one has successfully lived up to the most exacting requirements of one's role as scientist. The self-image of the individual scientist will also depend greatly on the appraisals by his scientific peers of the extent to which he has lived up to this exacting and critically important aspect of his role. As Darwin once phrased it, 'My love of natural science . . . has been much aided by the ambition to be esteemed by my fellow naturalists.' " (p. 293)

A4 The Reward System of Science

We cite several sentences related to the Merton's concept on the reward system of science below [Merton 1975];

" --- the heart of the Mertonian paradigm – the powerful juxtaposition of the normative structure of science with its institutionally distinctive reward system – as it provides a simplified but basic model of the structure and dynamics of the scientific community."[Merton 1975 (Storer, p. 281)]

"Not only is the essential character of the rewa4rd system set forth, but in coupling it with the normative system, Merton is able to make sense of the problems which develop out of the incommensurate imperatives of these two components of the institution." (p. 282)

"Several social pathologies of science are pinpointed as the results of specific discontinuities between the normative and the reward systems so that their investigation may contribute to a cumulating body of knowledge about science." (Storer, p. 282)

A5 The Processes of Evaluation in Science

The Chapter 5 titled "*The processes of Evaluation in Science*" of the Merton's Book [Merton 1975] is irrelevant to the CFP at present but is interesting to see the title of papers included in this Chapter (with ordering numbers in front of them):

19. *Recognition* and *Excellence*; Instructive ambiguities,
20. The Matthew Effect in Science,

21. Institutionalized Patterns of Evaluation in Science,
22. Age, Aging, and Age Structure in Science.

These themes taken up in the above papers will become our problems when the science of the cold fusion phenomenon is established. We cite several sentences from R.K. Merton [Merton 1975] below which are relevant our present researches.

"Matters of role performance (potential and achieved) and of recognition (instrumental and honorific) are central to all the papers, with attention focusing sequentially on the consequences of accumulated honorific recognition, the processes through which such recognition is acquired or denied, and the relevance of age (biological and social) to the preceding topics." [Merton 1975 (Storer, p. 415)]

"--- considers research questions important for the general problem of how excellence is recognized and rewarded or neglected and even penalized in society and now the effectiveness of these processes might be increased." [Merton 1975 (Storer, p. 415)]

"They then analyze the archives of the *Physical Review,* rather than only the distribution of papers actually published in that journal, to determine the kind of recognition received." [Merton 1975 (Storer, p. 416)]

"In science, according to the ideal norm of universalism, it is the quality of work, judged by peers against the current state of the art, that should entirely determine the kind of recognition received." [Merton 1975 (Storer, p. 418)]

A5-1 Funding Organization for the CFP

Main funding organizations for researches in the CFP are partially listed in Appendix H. It is seen that very few organizations are responding to the researches in this field due to the venturing nature of these researches.

Appendix B – Controlled Thermonuclear Fusion

We cite here the Chapter 9 of the Chen's textbook *Introduction to Plasma Physics* [Chen 1974] to show the controlled thermonuclear fusion had supplied the impetus for the growth of plasma physics and had been its important theme.

"**Chapter 9 Introduction to Controlled Fusion**

9.1 The Problem of Controlled Fusion

It is entirely fitting that this book should end with an introduction, since the study of elementary plasma physics leads to an understanding of the complex problem that originally supplied the impetus for the growth of this new science—the problem of controlled thermonuclear reactions. Since the only fuel required in the ultimate fusion reactor is the heavy hydrogen in seawater, the realization of this goal would mean a virtually limitless source of energy (lasting hundreds of millions of years) at virtually zero fuel cost. The enormous impact this would make on our civilization makes controlled fusion the most important scientific challenge man has ever faced." [Chen 1974]

"9.1.1 Reactions (numbers of equations are renamed as (A.1) for the original (9.1))
The first generation of fusion reactors will rely on the following reactions:

$$D + T \rightarrow {}^4He\ (3.5\ MeV) + n\ (14.1\ MeV) \qquad (A.1)$$

$$n + {}^6Li \rightarrow {}^4He\ (2.1\ MeV) + T\ (2.7\ MeV) \qquad (A.2)$$

Here, n is a neutron and D and T are atoms of deuterium (^2H) and tritium (^3H), respectively. This reaction, as we shall see, has the lowest ignition temperature and lowest confinement requirement of all. However, most of the energy comes out in the form of a 14-MeV neutron and has to be recovered in a heat cycle, whose thermodynamic efficiency is limited to about 40%. Furthermore, the neutron causes damage to the reactor walls.

A second disadvantage of reaction (A-1) is that tritium does not occur naturally and has to be bred via reaction (A-2) in a blanket of lithium surrounding the plasma. Fortunately, ^6Li is an abundant isotope, comprising 7.5%of natural lithium, of which the earth's crust has a copious supply. There is an inexhaustible supply of deuterium, since 0.015% of the hydrogen in sea water is deuterium, and it is easily separated out.

A reactor fueled with deuterium alone would undergo the following reactions, which occur with about equal probability:

$$D + D \rightarrow T\ (1\ MeV) + p\ (3\ MeV) \qquad (A\text{-}3)$$

$$D + D \rightarrow {}^3He\ (0.l8\ MeV) + n\ (2.5\ MeV) \qquad (A\text{-}4)$$

No tritium breeding is required, and only 34% of the energy appears in the form of neutrons. However, the requirements on the plasma are considerably more difficult to satisfy.

An attractive possibility in a fusion reactor is the use of the charged reaction products to generate electric power directly, thus avoiding the inefficiency of a thermal cycle and minimizing thermal pollution of the environment. If the high ignition temperatures can be achieved, the following reactions, which have only charged-particle products, would

be suitable for this purpose:

$D + {}^3He \rightarrow {}^4He + p + 18.3$ MeV,

$p + {}^6Li \rightarrow {}^4He + {}^3He + 4.0$ MeV, (A-5)

$p + {}^{11}B \rightarrow 3{}^4He + 8.7$ MeV."

[Chen 1974]

"9.1.2 The Necessity for Plasma

Since ions are positively charged, the Coulomb force of repulsion has to be overcome before the reactions of Section 9.1.1 can occur. Consequently, the nuclei have to be accelerated to considerable energy in order to penetrate the Coulomb barrier. For instance, the cross section σ for the D-T reaction rises sharply as energy is increased up to 50 keV. A peak in σ is reached near 100 keV, and σ decreases gradually at higher energies. A beam of deuterons from an accelerator cannot be used, for it can be shown that if the beam is directed at a target of solid tritium or deuterium, for instance, most of the energy is lost in ionizing and heating the target and in elastic collisions. Colliding beams cannot be made dense enough to give a fusion energy output larger than the energy required for acceleration. The solution is to form a Maxwellian plasma in which the fast particles in the tail of the distribution undergo fusion. Elastic collisions do not change the distribution function if it is Maxwellian, and the energy used to heat the plasma is retained until the particles react or escape from the chamber. This is the reason for the term *thermonuclear* reactions." [Chen 1974]

"9.1.3 Ignition Temperature

The power produced per cm3 in D-T reactions is

$$P_r = n_D n_T <\sigma v> W \quad \text{(A-6)}$$

where $<\sigma v>$ is averaged over the Maxwellian distribution, and W is the 17.6 MeV of energy released in each reaction. To maintain the plasma temperature, this power must exceed that which is lost. Even if the plasma were perfectly confined, there is an inescapable energy loss due to radiation by the electrons. This radiation, called bremsstrahlung, is emitted when electrons make elastic collisions with the ions and therefore radiate as accelerated charges. The bremsstrahlung power is given by

$$P_b = 5 \times 10^{-31} Z^2 n^2 (kT_e)_{keV}^{1/2} \quad \text{(A-7)}$$

Both P_r and P_b, vary as n^2, but P_r increases much more rapidly with kT than does P_b. An ignition temperature can be found by equating P_r to P_b and assuming that the product ions have enough time to transfer their energy to the other ions and to the electrons by Coulomb collisions, so that all the temperatures are equal. For the D-T

reaction, the ignition temperature is about 4 keV for the D-D reaction, it is about 35 keV. For the high-Z reactions of Eq. (A-5), even higher temperatures would be required." [Chen 1974]

"9.1.4 The Lawson Criterion

To produce more energy by fusion than is required to heat the plasma and supply the radiation losses imposes a condition on plasma density n and confinement time τ, as well as on the temperature. It is assumed that the fusion energy, the bremsstrahlung energy, and the kinetic energy of escaping particles (the escape rate is determined by τ) are all recovered thermally with an efficiency not exceeding 33%. It turns out that n and τ occur only in the Product $n\tau$. The minimum value of $n\tau$ required is about 10^{14} cm^{-3} sec for D-T and about 10^{16} cm^{-3} sec for D-D. This is called the *Lawson criterion*. It is possible in principle to lower these figures by using complex schemes, such as combining beams with Plasmas or by more efficient energy recovery, such as direct conversion to electricity." [Chen 1974]

"9.1.5 Major Problems

The problems involved in developing a fusion reactor may be divided into three general areas:

1. Plasma confinement
2. Plasma heating
3. Fusion technology .

Confinement has to do with satisfying the Lawson criterion on $n\tau$. There are two different approaches: confinement by magnetic fields, with $n = 10^{15}$ cm^{-3} and $\tau \sim 0.1$ sec, and inertia] confinement as in laser-produced fusion, in which $n \sim 10^{26}$ cm^{-3} and $\tau \sim 10^{-11}$ sec. Magnetic confinement has received the most attention and is the best understood of the above three areas. Plasma heating is, of course, related to confinement—even a slow heating process would be good enough if the confinement time were very long. The detailed mechanisms in heating are not yet understood. Fusion technology has to do with the engineering design of a reactor apart from the plasma aspects. The real problems in this field have yet to be faced.

In addition, we should add two subcategories on which considerable progress has been made:

1. Plasma diagnostics
2. Plasma purity

To measure the parameters of a plasma and what goes on inside it, a large variety of

diagnostic methods have been developed. These involve electromagnetic waves, plasma waves, internal probe electrodes, particle beams, and external sensors. Plasma purity is an experimental problem of considerable importance, since the influx of high-Z atoms from the walls causes rapid loss of energy by atomic radiation. There are devices, called divertors, made to isolate a hot plasma from the walls effectively.
A large number of ideas for achieving the plasma conditions for fusion have been tried; but although a few nonstandard methods are still being pursued, the main experimental efforts have narrowed down to the following four approaches:

1. Closed systems: toruses
2. Open systems: magnetic mirrors
3. Theta pinch
4. Laser-fusion" [Chen 1974]

"In closed systems, the lines of force are confined within the system, even if they do not close upon themselves. Open magnetic systems work on the mirror effect described in Section 2,3.3. Pinches are plasmas carrying sufficient current to generate their own magnetic fields. The current also serves to heat the plasma. The geometry can be either open or closed. Fusion by laser works on inertial rather than magnetic confinement and, if technically feasible, would obviate the problems of magnetic instabilities." [Chen 1974 (Section 9)]

Appendix C – ITER (International Thermonuclear Experimental Reactor)Story

To show the situation to overcome the difficulty in the realization of the controlled thermonuclear fusion projects, we cite here the explanation of the agreement to start the ITER (International Thermonuclear Experimental Reactor) project from ITER website [ITER 1985].

"The ITER Story

The launch of an international effort on fusion: US President Reagan and General Secretary Gorbachev of the Soviet Union at the Geneva Superpower Summit (1985).
Nearly 30 years ago, a group of industrial nations agreed on a project to develop a new, cleaner and more sustainable source of energy.

ITER was set in motion at the Geneva Superpower Summit in November 1985, when the idea of a collaborative international project to develop fusion energy for peaceful

purposes was proposed by General Secretary Gorbachev of the former Soviet Union to US President Reagan.

One year later, an agreement was reached: the European Union (Euratom), Japan, the Soviet Union and the USA would jointly pursue the design for a large international fusion facility, ITER. Conceptual design work began in 1988, followed by increasingly detailed engineering design phases until the final design for ITER was approved by the Members in 2001.

The People's Republic of China and the Republic of Korea joined the Project in 2003, followed by India in 2005. Selecting a location for ITER was a lengthy procedure that was concluded in 2005, when the ITER Members unanimously agreed on the site proposed by the European Union. The ITER installation would be built near Aix-en-Provence in southern France.

Further negotiations established the ITER Agreement to detail the construction, exploitation and decommissioning phases, as well as the financing, organization and staffing of the ITER Organization." [ITER 1985]

"The ITER Agreement

The ITER Agreement is signed at the Elysée Palace in Paris on 21 November 2006.
In a ceremony hosted by French President Jacques Chirac and the President of the European Commission M. José Manuel Durao Barroso, the ITER Agreement was officially signed at the Elysée Palace in Paris on 21 November 2006 by Ministers from the seven ITER Members; this document established a legal international entity to be responsible for the building, operating, and decommissioning of the Project. Following the ratification of the international treaty by all Members, the ITER Organization was officially established on 24 October 2007.

The first teams arrived on site in Saint Paul-lez-Durance, France in late 2005 after the site decision. From that moment until the start of building construction in 2010, staff was increased to approximately 500, the nuclear licensing process was initiated; site preparatory works were carried out, and procurement agencies in each ITER Member (the Domestic Agencies) were established.

Today, over 2,000 people are collaborating at the ITER site in Saint Paul-lez-Durance,

France and in China, the European Union, India, Japan, Korea, Russia and the United States to build the ITER Tokamak, the world's most advanced tokamak magnetic confinement fusion experiment." [ITER 1985]

Appendix D Controversy between Pros and Cons on the Possibility of *d-d* Fusion Reactions in CF Materials

From the point of view looking for a sustainable economic energy source, the cold fusion is an alternative of the controlled thermonuclear fusion of deuterons which have been earnestly investigated all over the world since 1950s. The motivation of the pioneering research by M. Fleischmann and S. Pons was just to realize the $d - d$ fusion reactions in palladium metals charged with deuterium (PdD_x) by the electrolytic method [Fleischmann 1989, 1990]. There have been severe controversies between pros and cons on the possibility of $d - d$ fusion reactions in transition metal deuterides as briefly reproduced below. From the point of view to establish the science of the cold fusion phenomenon, this controversy is counterproductive and has given negative effects on the investigations of the science of nuclear reactions occurring in the CF materials (materials where occur the cold fusion phenomenon).

D1 Persistence to the Deuterium System – Influence of Plasma Fusion Research

Proponents and opponents of the cold fusion phenomenon altogether have been trapped in the web of the deuteron-deuteron fusion reactions supposed in the frame-work of the plasma fusion (cf. Appendix B and C).

We cite here representative insistences by proponents, M. Fleischmann, S. Jones, and opposing arguments by opponents, J.R. Huizenga and D.R.O. Morrison.

J.R. Huizenga was the co-chairman of the United States Department of Energy – Energy Research Advisory Board Cold Fusion Panel and also the author of *Cold Fusion: The Scientific Fiasco of the Century* (cf. Appendix D4b and [DOE 1989, Huizenga 1992]).

D.R.O. Morrison was a Professor of the CERN laboratory in Geneva, Switzerland. He published the *Cold Fusion News* (1989-1990) and *Cold Fusion Updates* (1990-2000) electronically and expressed his views on the CFP (cf. [Morrison I, 1990, II]).

D1a Discovery of a cold fusion reaction in solids at near room temperature by M. Fleischmann et al. by accident [Fleischmann 1989]

“Discussion

We realise that the results reported here raise more questions than they provide answers, and that much further work is required on this topic. The observation of the generation of neutrons and of tritium from electrochemically compressed D^+ in a Pd cathode is in itself a very surprising result and, evidently, it is necessary reconsider the quantum mechanics of electrons and deuterons in such host lattices. In particular we must ask: is it possible to achieve a fusion rate of 10^{-19} s^{-1} for reactions (v) and (vi) for clusters of deuterons (presumably located in the octahedral lattice positions) at typical energies of 1 eV? Experiments on isotopically substituted hydrides of well-defined structures might well answer this question.

The most surprising feature of our results however, is that reactions (v) and (vi) are only a small part of the overall reaction scheme and that the bulk of the energy release is due to an hitherto unknown nuclear process or processes (presumably again due to deuterons).” [Fleischmann 1989 (p. 308)]

D1b Following the idea expressed by M. Fleischmann, a feature is confirmed by S. Jones et al. [Jones 1989]

“Conclusions

The correlation of ideas regarding cold piezonuclear fusion[1] with observations of excess ^{3}He in metals and in geothermal areas of the Earth led to our experimental studies of fusion in electrochemical cells, which began in May 1986. Our electrolyte compositions evolved from geochemical considerations, and changed as results were observed. The presence of a fusion neutron signal was consistently reproduced, although the rate varied widely. Now that our exploratory searches have disclosed a small piezonuclear fusion effect, it remains to disentangle the factors that influence the fusion rate.” [Jones 1989 (p. 740)]

D1c Examination of the experimental data on the CFP; the facts were denied based on the common sense of physics [DOE 1989]

The Committees in the Department of Energy had been composed of experts in relevant fields to the CFP and their technical opinions should be esteemed. It should, however, be pointed out limitations imposed on them by their duty different from the researchers in this field. Their duty binds them to confine their sight and also their expertise limits their investigation of the data in of the CFP inside their field preventing extension of their sight (cf. [Kozima 2016a (Section 2)]).

The characterization of the *DOE Report* presented in 1989 [DOE 1989] was given in our book [Kozima 1998a (pp. 3 – 7)]. We can cite our conclusion below on the DOE Report 1989;

"*Let us point out mistakes in the DOE report.*

Conclusion (1) is based on Conclusions (2) ~ (5), and it has no basis if Conclusions (2) ~ (5) are incorrect. The issue of excess heat and fusion products discussed in Conclusion (2) has significance only when D + D reaction is assumed as the main process. This assumption was adopted by the majority of the scientists at that time, including those who discovered cold fusion.

If there is some other mechanism governing the process, this argument is no longer valid. If you are searching for truth, whether one assumption made by a scientist is correct or not has no importance. You should search for the truth based on the fact that the phenomenon did occur. From this point of view, we will show, in Chapters 11 and 12, that it is possible to explain the results of cold fusion experiments without any inconsistency.

Conclusion (3) was based on the fact that the cold fusion phenomenon presented poor reproducibility. However, the reproducibility of a phenomenon is determined by the condition of the entire system, in which the process takes place. Simple analogy from other physical phenomena should not have been used to draw a conclusion. We will also show the reasons for the poor reproducibility and the way to improve it in Chapters 11 and 12.

Conclusion (4) only shows that the interpretations of the discoverers of cold fusion were not appropriate, and it has nothing to do with the truth. It is hard to believe that board members have made such an elementary mistake. It was found later that inside solid, such as Pd or Ti, with a combination of various factors, complex phenomena can occur. There is always such possibility in science. Today, it is quite obvious to everybody. The board members might have forgotten for some reason that natural science is built upon the fact.

Conclusion (5) is similar to Conclusion (4). If any new findings had been denied only because they were contradiction with the existing knowledge, there would have been no progress in science and there will not be any progress in the future.

The discussions expressed in the DOE Report remind us Procrustes' bed. As Procrustes used his bed as an absolute standard to measure heights of his captives, the critiques against the cold fusion used d – d reaction as an inevitable standard to judge anomalous events." [Kozima 1998a]

A scientific spirit in the *Report* is sparkling in the following sentence added as a comment (believed to be written by N.F. Ramsey);
"- - - *as a result, it is difficult convincingly to resolve all cold fusion claims since, for example, any good experiment that fails to find cold fusion can be discounted as merely not working for unknown reasons. Likewise the failure of a theory to account for cold fusion can be discounted on the grounds that the correct explanation and theory has not been provided. Consequently, with the many contradictory existing claims it is not possible at this time to state categorically that all the claims for cold fusion have been convincingly either proved or disproved* - - - ." [DOE 1989]

D1d Opponents raised their hands in the framework of traditional physics on the same line of DOE giving no insight into truth [Morrison I]
"Now we are in phase two where we do not need more press releases but experiments with good measuring devices and serious controls that would convince other scientists. In working on cold fusion, one is quickly aware of the great knowledge gap between electrochemists and particle physicists and also the different cultures and jargon. An ideal team would include both electrochemists and particle physicists." [Morrison I (No. 6 (April, 1989))]

His failure to confirm the CFP in accordance with his knowledge of nuclear physics may have made him an enthusiastic opponent against the CFP.

D1e Proponent remained on the same stance as the original one struggling throwing himself on new idea [Fleischmann 1990]
An Overview of Cold Fusion Phenomena by M. Fleischmann;,
"There were (and are) a number of further factors which point to the possibility of inducing nuclear reactions of electrochemically compressed deuterium. The dissolved D^+ is, in fact, a very high density, low ion temperature plasma existing in a high electron concentration." [Fleischmann 1990 (p. 346)]
" For the Pd-D system the central conundrum, the disparity of the excess enthalpy generation and of the expected nuclear products according to reactions (i) and (ii) however remains unsolved. It is clear that there must be *other nuclear reaction paths* of high cross-section and that these will only be discovered by a careful search for products on the surface and in the bulk of the electrodes (as well as in the solution and gas spaces)." [Fleischmann 1990 (p. 348)] (Italicized at citation).

Martin Fleischmann had considered in the early stages of CF research that "the cold fusion" as he supposed to be was induced essentially by *d-d* fusion reactions but resulting in various "phenomena" tabulated in Table 3.1 as cited below [Fleischmann 1990 (Table 1)]. The words "Cold Fusion Phenomena" used by him in this paper [Fleischmann 1990] show clearly his concept on the cold fusion phenomenon (CFP), in our words, that the CFP is composed not only of phenomena (events in our word) producing the products by ordinary reaction formulae

$D + D \rightarrow T\ (1\ MeV) + p\ (3\ MeV)$, (D-1)

$D + D \rightarrow {}^{3}He\ (0.l8\ MeV) + n\ (2.5\ MeV)$, (D-2)

and

$D + D \rightarrow {}^{4}He\ (0.08\ MeV) + \gamma\ (23.8\ MeV)$, (D-3)

but also of unknown reactions between deuterons, *other nuclear reaction paths*.

At this stage (in the year 1990), he has accepted the experimental results shown in Table D.1 (Table 1 of [Fleischmann 1990]) as "phenomena" induced by *d-d* fusion reactions not recognizing the vast variety of the phenomena (events) impossible to be explained by the *d-d* fusion reactions as shown later not only in deuterium systems but also in protium systems which have come out one after another soon from this year [Mills 1991, Noninski 1991, 1992, Bush 1992]. It should be also noticed that at this stage, there are no data of nuclear transmutations generating elements with different proton and nucleon numbers from elements preexisted in the system at all.

Thus, the word "phenomena" used by Fleischmann in this period reflects his concept on the events observed hitherto in the systems composed of transition metals and deuterium as a variety of results of *d-d* fusion reactions. In this meaning, the "phenomena" should be replaced by a word "events" expressing variety of results of the *d-d* fusion reactions known in nuclear physics and written down above.

We have proposed to use the name the "cold fusion phenomenon" ("CFP" in short) for the whole events caused by nuclear reactions in CF materials observed in this field including those written in the Table D.1 (Table 1 of [Fleischmann 1990]) keeping the term "cold fusion" used from 1989 and unifying whole events observed hitherto even if they have not fully explained yet.

"

Table D1 The various phenomena which have been reported so far in the course of this research by the year of 1990 [Fleischmann 1990 (Table 1)].

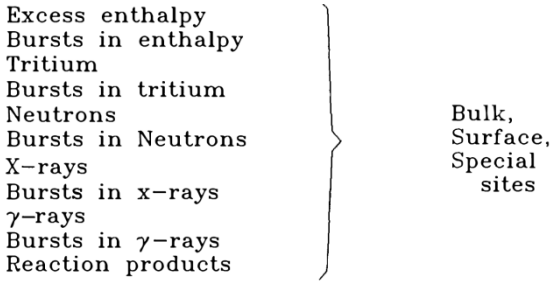

Table I. The various phenomena which have been reported so far in the course of this research.

“

D1f Opponents remained on the conventional stance without insight into truth behind facts [Morrison 1990, II]

“Experimental results on Cold Fusion are reviewed. Most experiments find no effect and the upper limits are appreciably lower than the positive effects claimed in some experiments. It is concluded that (a) there is no excess heat production, (b) the balance of evidence is strongly against fusion products.” [Morrison 1990 (Abstract)]

“I am reluctant to give up well-established laws of Nature unless the proof is very strong. Here reports on cold fusion happenings are described, especially in the summary talks by True Believers in cold fusion in their words, and then some clues as to possible explanations are offered. How many Elvis sightings constitute a proof?” [Morrison II (No.13 (July, 2000) Conclusion)]

Here is a typical attitude of unscientific thinking; discard facts which are in contradiction with the “well-established laws of Nature” instead of accepting the facts and to seek clues to reconcile them with the laws of Nature.

D2 Fundamental attitude of proponents and oppositions

The discussions between pros and cons have been given mainly whether the *d-d* fusion reactions have occurred in CF materials, mainly PdD_x alloys at first stage of the discussion. We have noticed this discussion is unproductive as far as we confine our investigation only in the possibility of the *d-d* fusion reactions in CF materials not

extending our sight out to other reactions resulting into the observed experimental products.

D2a Proponents; M. Fleischmann:

Based on the experimental data showing huge excess heat inexplicable by probable chemical reactions in the CF materials, pros or proponents insist that *d-d* fusion reactions are occurring in the CF materials (e.g. [Mallove 1991]).

M. Fleischmann had expressed his credo several times in his papers. The first was at ICCF1 (1990) and the recent one was in his paper presented at ICCF7 (1998);

[Fleischmann 1990] M. Fleischmann, "An Overview of Cold Fusion Phenomena," *ICCF1 lecture* (**March 31**. 1990, Saturday), *Proc. ICCF1*, pp. 344 – 350 (1990).

[Fleischmann 1998a] M. Fleischmann, "*Cold Fusion: Past, Present and Future,*" in "*Abstract of Proc. ICCF7.*"

[Fleischmann 1998b] M. Fleischmann, "*Cold Fusion: Past, Present and Future,*" *Proc. ICCF7*, pp. 119 – 127 (1998). ENECO Inc., Salt Lake City, Utah, USA.

Even if Fleischmann realized the explanation of the *d-d* fusion reactions (D-1) – (D-3) are difficult to occur in CF materials such as PdD_x, he expected some mechanisms, e.g. quantum field theoretical one to realize *other nuclear reaction paths.* [Fleischmann 1990 (p. 348)]

D2b Opponents; Huizenga, Morrison and Taubes

Based on the knowledge of quantum mechanics, solid state physics, and nuclear physics, cons or contras oppose or criticize the idea of *d-d* fusion reactions in solids proposed by the pioneers of the CFP (e.g. [DOE 1989, Morrison 1989, Morrison 1990, Huizenga 1992, Taubes 1993]).

Their logic is, in short, that the facts contradicting to the known laws of physics are not true. This logic is a too simple to be taken sincerely but perhaps is a logic taken to counterbalance the insistence of proponents. Opponents have no desire to find out truth through the facts revealing something behind them.

D3 Citations from papers by pros and cons;

In this subsection, we cite several sentences from papers by pros and cons to illustrate their strong persistence to the *d – d* fusion reactions.

D3a. Proponent, Mallove accepts the *d – d* fusion reactions naively

"It is now reasonably clear that fusion reactions that liberate energy—near but very peculiar relatives of nuclear processes that are the lifeblood of the stars—can occur at

room temperature. There is no chance whatever that cold fusion is a mistake." [Mallove 1991 (preface p. x)]

D3b. Opponents, DOE, J.R. Huizenga, D.R.O. Morrison and G. Taubes deny the *d* – *d* fusion reactions in CF materials

"A major fraction of experimenters making calorimetric measurements, either with open or closed cells, using Pd cathodes and D_2O, report neither excess heat nor fusion products. Others, however, report excess heat production and either no fusion products or fusion products at a level well below that implied by reported heat production. Internal inconsistencies and lack of predictability and reproducibility remain serious concerns." [DOE 1989 (B. Conclusions, Sec. 2)]

"There is no reason to think that these branching ratios (of *d*-*d* fusion reactions, added at citation) would be measurably altered for cold fusion. Therefore, if the Fleischmann-Pons claims of watts of excess heat were due to fusion between deuterium nuclei, large amounts of easily detectable fusion products[2)] would have to be present. In fact, one watt of power from nuclear reactions (1) must have associated with it approximately 10^{12} (one million million) neutrons per second, neutrons being the fusion product most easily detected by direct counting.
2) Even if the branching ratios for cold fusion were very different, large amounts of fusion products would still have to be present." [Huizenga 1992 (p. 7)]

"The major conclusion is that all the measurements of fusion products agree that any possible fusion rate is many orders of magnitude less than would be needed to account for any positive measurement of excess power that is claimed." [Morrison I (No. 14, 4.6 Summary)]

"Within six months of the announcement of cold fusion, its public life had deteriorated into a dismaying struggle against reality in which the believers explained the insipid state of their science with all manner of causes, none of which was as simple as the reality itself. Cold fusion—as defined by Stanley Pons and Martin Fleischmann, or Steve Jones, or as modified by John Bockris or Edmund Storms and Carol Talcott, or Bob Huggins-Stanford, or whomever—did not exist. It never had. There was at least as much empirical evidence, if not more, to support the existence of any number of pseudoscientific phenomena, from flying saucers to astrology." [Taubes 1993 (p. 425)]

D4 Remarkable books on the CFP at early stage

There have been several books published by proponents to support and opponents to deny the *d-d* fusion reactions in CF materials [Mallove 1991, Huizenga 1992]. We cite here several typical sentences from two books by E.F. Mallove and J.R. Huizenga.

D4a E.F. Mallove; *Fire from Ice – Searching for the Truth Behind the Cold Fusion Furor* – [Mallove 1991]

Mallove introduced the cold fusion phenomenon with too optimistic mind as an entity of real science showing production of excess energy to be used for energy sources in our industrial society based on partial experimental data sets obtained mainly in deuterium systems by the year 1991.

His declaration reflects his hastened conclusion to try justification of the d-d fusion reactions supposed by the frontiers of the CFP;

“It is now reasonably clear that fusion reaction that liberate energy—near but very peculiar relatives of nuclear processes that are the lifeblood of the stars—can occur at room temperature.” [Mallove 1991 (p. x)]

“Now that many more facts are available and the furor has quieted down, the story can be told in its delicious and delirious detail. This is an account of the unfolding of a new phenomenon – the scientific process observed.” [Mallove 1991 (p. x)]

In this book, Mallove was conscious of some problems involved in science of modern society;

“We will explore the scientific intrigue and infighting that occurred in the cold fusion revolution, which provided much human drama. There were fights to publish and to forestall publication, issues of priority of discovery, funding matters, misinformation and disinformation, rumors that became "fact," questions of academic standing, and even allegations of scientific deceit.” [Mallove 1991 (p. xii)]

The problems picked up by him were listed up as follows [Mallove 1991 (p. xii – xiv)]:

* Spectacular resistance to paradigm shifts in science is alive and well.
* The majority does not rule in science.
* It is dangerous and often deceptive to make analogies between one scientific controversy and another.
* Irving Langmuir's rules for identifying so-called "pathological science" are best retired to the junk heap for prejudice and name calling.
* Ockham's Razor is too easily forgotten. In science, the simplest unifying theory or connection is often most appropriate.

* Use extreme caution in dismissing experimental results just because theory suggests they are "impossible."
* The fear that possible scientific error would be ridiculed, or worse, interpreted as fraud, is stultifying.
* The peer review process by which articles make their way into journals is not infallible.
* Vested scientific interests are not easily persuaded to share their resources.

In conclusion of his investigation of experimental data on the CFP, E.F. Mallove exclaimed as follows;
"An essential caveat: After reviewing mounting evidence from cold fusion experiments, I am persuaded that it provides a compelling indication that a new kind of nuclear process is at work. I would say that the evidence is overwhelmingly compelling that cold fusion is a real, new nuclear process capable of significant excess power generation." [Mallove 1991 (p. xv)]

D4b J.R. Huizenga; *The Scientific Fiasco of the Century —The Scientific Fiasco of the Century* [Huizenga 1992]

Huizenga discussed whole problem from a point of view that everything is results of the reactions (1a) – (1c) and accused data in contradiction with his assumption.
"D + D → [^{4}He]* →
^{3}He (0.82 MeV) + n (2.45 MeV) (1a)
T (1.01 MeV) + p (3.02 MeV) (1b)
^{4}He (0.08 MeV) + gamma ray (23.77 MeV) (1c) "
[Huizenga 1992 (p. 6)]

"The reactions (1a) and (1b) have been studied over a range of deuteron kinetic energies down to a few kiloelectron volts (keV) and the cross sections (production rates) for these two reactions have been found experimentally to be nearly equal (to within ten percent). Hence, the fusion of deuterium produces approximately equal yields of 2.45 million-electron-volts (MeV) neutrons (with an accompanying ^{3}He atom) and 3.02-MeV protons (with an accompanying tritium atom). This near-equality of the neutron and proton branches (production rates) is expected also on the basis of theoretical arguments. The cross section (production rate) for reaction (1c) is several orders of magnitude lower than reactions (1a) and (1b). This well-established experimental result is consistent with the Bohr model which predicts that the compound nucleus will decay

predominantly by particle emission [reactions (1a) and (1b)], as opposed to radiative capture [reaction (1c)], whenever it is energetically possible." [Huizenga 1992 (p. 7)]

"Based on present experimental evidence, the branching ratios for the three reactions shown by Equation (1) appear to be essentially constant at low energies. There is no reason to think that these branching ratios would be measurably altered for cold fusion. Therefore, if the Fleischmann-Pons claims of watts of excess heat were due to fusion between deuterium nuclei, large amounts of easily detectable fusion products[2] would have to be present. In fact, one watt of power from nuclear reactions (1) must have associated with it approximately 10^{12} (one million million) neutrons per second, neutrons being the fusion product most easily detected by direct counting." [Huizenga 1992 (p. 7)]

"The secrecy surrounding Fleischmann and Pons' experiments on campus prior to the March 23 press conference caused major problems. The secrecy prevented open debate and discussion. This can be best illustrated by the fact that the University of Utah scientists and administrators did not ever consult members of their own physics department before announcing cold fusion to the world. To have made an announcement, of what appeared at that time to be a major scientific breakthrough in nuclear fusion, without seeking expert opinion from the physicists on campus was a serious intellectual and administrative mistake. When physicists and chemists around the United States learned through the news media about the claims of Fleischmann and Pons, they contacted their physicist and chemist colleagues at the University of Utah. It was with total disbelief that the scientific community outside Utah learned that the University of Utah physicists had been completely unaware of both the impending announcement and the cold fusion research on their own campus! No doubt the rivalry between the University of Utah and Brigham Young University, known to be near publication of its own cold fusion work, closed the debate between the two scientific groups and pressured the University of Utah officials into a premature press conference. Even so, it is hard to understand how university officials could go public on such a major claim, involving nuclear physics at its deepest level, without consulting and involving the physicists on campus. This neglect is even more striking because James Brophy, vice president for research and chief spokesman for the administration, is a physicist by training, and knew of the discrepancy between the expected nuclear products and the findings of Fleischmann and Pons." [Huizenga 1992 (p. 11)]

D5 Sociological comments on the conflict between pros and cons

It is interesting to notice that the controversies fought between pros and cons briefly introduced above have been discussed by R.K. Merton in the more general context as follows;

"--- The coexistence of these conflicting perspectives and interpretations within the same society leads to an active and reciprocal *distrust* between groups. Within a context of distrust, one no longer inquires into the content of beliefs and assertions to determine whether they are valid or not, one no longer confronts the assertions with relevant evidence, but introduces an entirely new question: how does it happen that these views are maintained? Thought becomes functionalized; it is interpreted in terms of its psychological or economic or social or racial sources and functions. In general, this type of functionalizing occurs when statements are doubted, when they appear so palpably implausible or absurd or biased that one need no longer examine the evidence for or against the statement but only the grounds for its being asserted at all.8 Such alien statements are "explained by" or "imputed to" special interests, unwitting motives, distorted perspectives, social position, and so on." [Merton 1973 (pp. 8 – 9)]

It is considered that the characteristics of human beings in living things on the Earth are their recognition of Truth, Beauty and Virtue. It seems, however, that they are in our mind in different depth, in the reverse order from the bottom to the surface. The order may be according to the order we obtained them in our history.

Appendix E – Competition for Funds

Taubes published a book [Taubes 1993] in which he investigated details of trials to get funds for researches from funding organizations in USA where it is imperative to get a fund to start and continue scientific researches compared with other industrial countries such as Italy, Japan and Russia. The competition for funds has been a cause of deviation of CF research from the ordinary route of progress of science.

A few phases of the competition have been cited below for illustration [Taubes 1993];

"*Alan Bewick, an electrochemist at Southampton who was Pons's thesis adviser and Fleischmann's colleague, recalled that Fleischmann had first aired his theory of cold fusion at Southampton back in 1974 or 1975, "before Stan was even heard of." Although Fleischmann kept talking about it, however, he never got around to trying it, nor did he find a colleague at Southampton who considered it worthy enough to pursue. "When he went to Utah [in the early 1980s]," Bewick said, "it gave him the opportunity to actually*

try out these mad ideas.'"" [Taubes 1993 (p.15)]

"*The operative fact in the release is the propitious 'five-and-a-half' years of work. This sets the origin of cold fusion around October 1983, at least one year before the meltdown and some two years before the earliest date given by Steve Jones's competing experiment at Brigham Young University. It is also a month or so after Pons left the University of Alberta and arrived in Utah and around the time Fleischmann took his early retirement at Southampton and became an honorary research professor. It is, coincidentally or not, the earliest date Utah could establish for cold fusion conception that might avert a legal claim from either Alberta or Southampton.*" [Taubes 1993 (pp. 16 – 17)]

"*For Pons and Fleischmann, "the meltdown" or "the explosion," as it came to be called, was the pivotal event in their research. It most likely occurred in the autumn of 1984, or the winter of 1985 and represented the dramatic culmination^ Pons and Fleischmann's very first, primitive experiment in cold fusion. They had suspended a solid, one-cubic-centimeter palladium electrode from a palladium wire in a large beaker. The beaker was filled with a cocktail of heavy water and lithium. They charged the contraption by passing a current between the palladium electrode and a second electrode (if their future experiments were any indication) made of platinum.*" [Taubes 1993 (pp. 3 – 4)]

- **Competition**

"In any case, before Jones could compose his own proposal to study piezonuclear fusion, Gajewski sent both him and Rafelski a proposal to review entitled "The Behavior of Electrochemically Compressed Hydrogen and Deuterium," by B. Stanley Pons and Martin Fleischmann. Sometime after Jones had received it, Paul Palmer had the following discussion with him:

"I've got this strange proposal that disturbs me," Jones said. "I don't know what to do about it."

"Oh, what's it about?" Palmer asked.

"Well, it's confidential," said Jones. "I better not tell you. But it could be a possible conflict of interest."

"Well," said Palmer, "who's it from?"

"I wish I hadn't told you," said Jones. "I wish I hadn't said anything about it."

"Well," Palmer said, "I now know what it's about or you wouldn't talk to me about it.

It's .about cold .fusion. "
End of conversation. Jones wouldn't say any more." [Taubes 1993 (p. 35)]

- **Preliminary Notes**

Press Release on March 23, 1989.

"*In the March 23, 1989, press release announcing the discovery of cold fusion, Stan Pons noted that the odds of successfully generating a nuclear fusion reaction in a test tube were a billion to one against. He also said that the experiment, in theory, "made perfectly good scientific sense." Thus he and Martin Fleischmann had initiated their paradoxical exercise in nuclear research "for the fun of it" and to satisfy scientific curiosity. Once they performed the experiment, however, they had "immediate indication that it worked."*

When asked at the press conference what this evidence was—"when you discovered that this one chance in a billion comes through," as a reporter phrased the question—Fleischmann told how they had induced what appeared to be a nuclear meltdown in a cube of palladium. "The thing which really triggered the whole thing off fairly early on," Fleischmann said, "was that we realized that you could generate a lot of heat, a lot." [Taubes 1993 (p. 3)]

The hastened publication of the experimental data with words "Preliminary Notes" [Fleischmann 1989] may be obtained in several years as described by Taubes as "*The operative fact in the release is the propitious 'five-and-a-half' years of work.*" [Taubes 1993 (p. 16)]

It should be noticed a sentence in the Fleischmann-Pons-Hawkins paper "T*he most surprising feature of our results however, is that reactions (v) and (vi) are only a small part of the overall reaction scheme and that the bulk of the energy release is due to an hitherto unknown nuclear process or processes (presumably again due to deuterons).*" [Fleischmann 1989 (p. 308)]
In this citation, the reactions (v) and (vi) are written as follows;

$^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{1}H$ (1.01 MeV) + $^{1}_{1}H$ (3.02 MeV) (v)

$^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He$ (0.82 MeV) + n (2.45 MeV) (vi)

Reflecting the sentence in the first paper by Fleischmann et al. cited above, Fleischmann used words "cold fusion phenomena" to express the phenomenon they have discovered by chance guided by the erroneous presumption of d-d fusion reactions in

PdDx alloy as the title “An Overview of Cold Fusion Phenomena” given at ICCF1 in 1990. [Fleischmann 1990]

[ICCF1 1990]

3:45 “An Overview of Cold Fusion Phenomena” M. Fleischmann, University of Utah/NCFI (**March 31**. 1990, Saturday)

Appendix F – Main Journals where published papers on the Cold Fusion Phenomenon after 1989.

Main periodicals where published papers on the CFP are listed in Section F1. The decision of Dr. G.H. Miley, the Editor of the Fusion Technology (FT) in 1990 was valuable for the development of this field. His comments are cited in Section F3.

F1. Journals where published papers on the cold fusion phenomenon.

There are several periodicals where published papers on the CFP. Some periodicals gave a space for the CFP but closed their door soon after the explosion of confusion on the facts and explanation. Some started their lives and terminated in few years due to own affairs. Periodicals published by authorized societies such as Japanese J. of Applied Physics and European J. Physics have accepted papers on the CFP according to their quality and direction in terms of the policies of the periodicals. The course of the periodicals figured out in Fig. E1 shows a phase of our history of the CFP research.

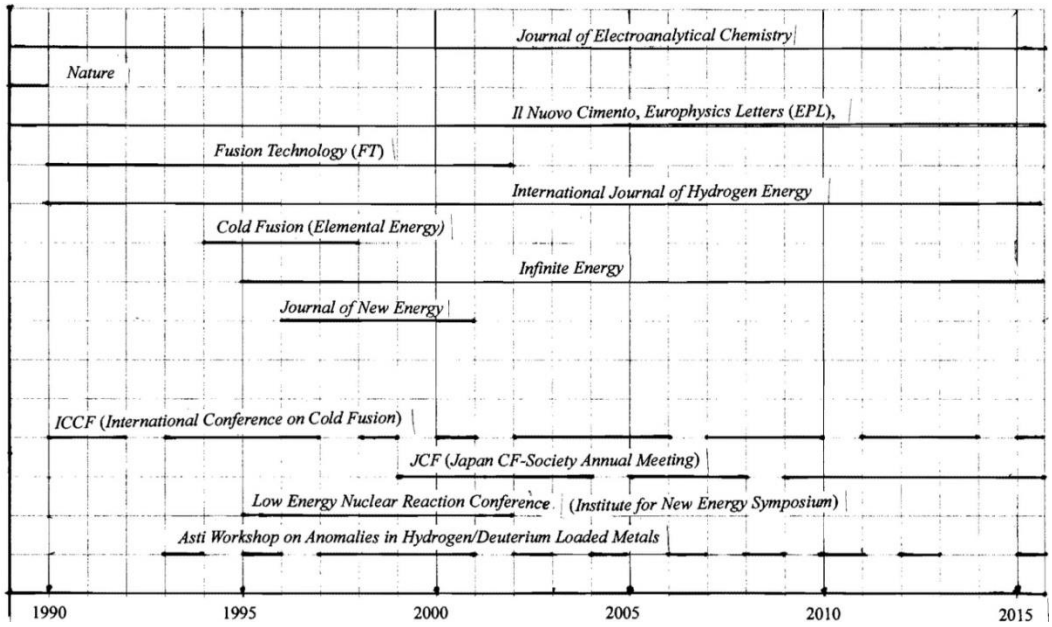

Fig. F1 Periodicals and International Conferences on the Cold Fusion Phenomenon until 2015

F1-1 Main periodicals on the CFP and their lives.

See Fig. F1 for the pictorial durations of these periodicals.

***Cold Fusion*, *Elemental Energy* (*Cold Fusion*)**, ISSN 1074-5610 (1994 – 1998)

Tables of Contents of this journal from Vol.1 to Vol 28 are posted at CFRL websites;

http://www.geocities.jp/hjrfq930/Papers/paperc/paperc.html

European J. of Physics (Il Nuovo Cimento) ISSN (1994 –)

***Fusion Technology*,** ISSN 0748-1896 (1989 – 2001)

Il Nuovo Cimento, ISSN: 0029-6341 (1989 –)

Infinite Energy (1995 –-)

International Journal of Hydrogen Energy, ISSN 0360-3199, (1989 –)

Japanese J. of Applied Physics, ISSN

J. Electroanalytical Chemistry, ISSN 1572-6657, (1989 –)

J. New Energy, ISSN 1086-8259, (1996 – 2001)

Nature ISSN (1989)

F1-2 Appendix to F1.

The Cold Fusion Research Laboratory (CFRL), directed by H. Kozima, has been publishing papers on the cold fusion phenomenon (CFP) written by the members of the CFRL as

***Reports of the Cold Fusion Research Laboratory*,** (2004 –).

The papers are posted at CFRL website;

http://www.geocities.jp/hjrfq930/Papers/paperr/paperr.html

Recently, the International Society for Condensed Matter Nuclear Science, has been publishing

J. Condensed Matter Nuclear Science - Experiments and Methods in Cold Fusion

from 2010. The papers published in the Journal are posted at following website;

http://lenr-canr.org/acrobat/ BiberianJPjcondensedv.pdf

F2. Papers on CFP in protium systems published in *Fusion Technology* (FT) (1991 – 1995)

FT Vol. 20 (1991) No. 1

(TECHNICAL NOTES ON COLD FUSION)

p. 65 *Excess Heat Production by the Electrolysis of an Aqueous Potassium Carbonate Electrolyte and the Implications for Cold Fusion* / *Randell L. Mills, Steven P. Kneizys*

FT Vol. 21 (1992) No. 2

p. 163 *Excess Heat During the Electrolysis of a Light Water Solution of K_2CO_3 with a Nickel Cathode* / *V. C. Noninski* (This paper was also presented at ICCF2 as only one paper on the protium system in this Conference).

FT Vol. 22 (1992) No. 2

p. 301 *A Light Water Excess Heat Reaction Suggests That "Cold Fusion" May Be "Alkali-Hydrogen Fusion"* / *Robert T. Bush*

FT Vol. 24 (1993) No. 2

p. 202 *Cold Fusion by Electrolysis in a Light Water-Potassium Carbonate Solution with a Nickel Electrode* / *Reiko Notoya*

FT Vol. 24 (1993) No. 3

p. 293 *Excess Heat Evolution During Electrolysis of H_2O with Nickel, Gold, Silver, and Tin Cathodes* / *Tadayoshi Ohmori, Michio Enyo*

FT Vol. 26 (1994) No. 2

p. 179 *Tritium Generation and Large Excess Heat Evolution by Electrolysis in Light and Heavy Water-Potassium Carbonate Solutions with Nickel Electrodes* /*Reiko Notoya, Yohichi Noya, Toshiyuki Ohnishi*

FT Vol. 26 (1994) No. 3

(NUCLEAR REACTIONS IN SOLIDS)

p. 261 *Anomalous Reactions During Arcing Between Carbon Rods in Water*/R. Sundaresan, J. O'M. Bockris

F3. G.H. Miley; Editor's Comments on the Cold Fusion Papers

The journal *Fusion Technology* ISSN: 0748-1896, an international journal of the American Nuclear Society, had a tremendous role on the development of the cold fusion research in its important period for a few years after 1989 when it is very difficult to publish papers on the interdisciplinary field between solid state physics and nuclear physics. The decision of the Editor, G.H. Miley at that time, should be esteemed very high as a symbol of scientific spirit to venture into an unknown field. To commemorate the Editor's courageous decision, we cite here two comments, one the "call for the cold fusion papers" and another the "farewell to the *FT*."

F3-1 G.H. Miley, "Call for technical notes on cold fusion in *Fusion Technology*," *Fusion Technology* Vol. 16, p. 116 (1989), ISSN 0748-1896.

"In view of the rapid pace in developments related to cold fusion, we intend to run, in upcoming issues of *Fusion Technology* (*FT*), a series of brief "technical notes" on that subject. The technical note section in *FT* is a standard feature intended for fast

publication of important papers on new directions, innovative ideas, and new results. Thus, this section seems to be ideally suited for rapid communication of work in progress in cold fusion.

Technical notes do not have a page limit, but they typically run two to four journal pages (roughly three double-spaced typewritten pages per journal page). A very brief abstract is required; otherwise, the format follows that for standard manuscripts (see "Instructions to Authors" on the inside back cover of the journal). Computer disks with ASCII-format word processing can be accepted per instructions in the July issue of the journal.

Technical notes will receive a review, but this process is set up for a rapid turnaround. Reviewers are instructed to consider technical notes (versus normal manuscripts) as speculative, sometimes incomplete, work that should be judged on the basis of innovation, originality, and importance to fusion power development. Appropriate citations to prior work are also essential.

Deadlines for receipt of technical notes for upcoming issues of FT are as follows:
September issue; May 5 deadline past
November issue: June 30 deadline past
December issue: August 4
January issue: September 5.
Several technical notes have already been received for the September issue so we hope that this represents a start for articles on cold fusion.

Send manuscripts to George H. Miley, Editor, Fusion Technology, Fusion Studies Laboratory, University of Illinois, 103 S. Goodwin Avenue, Urbana, IL 61801. If sending by Fax, use at (217) 333-2906. Any questions should be addressed to George H. Miley or Chris Stalker at (217) 333-3772."

F3-2 G.H. Miley, "As an Editor of the Fusion Technology" *Fusion Technology*, 38, iii (November 2000), ISSN 0748-1896. (excerpt)

"*It is with deep sadness that I retire in June 2001 as editor of Fusion Technology (FT). Despite the extensive time involvement, I have immensely enjoyed serving as editor. Discussions with authors and reviewers were continuously stimulating, and I always enjoyed a feeling of satisfaction from providing this service to the fusion community and to the American Nuclear Society (ANS). There were, of course, a few downsides, largely concerned with occasional financial struggles, debates over rejected manuscripts, and continued attempts to control paper backlogs that slowly oscillated back and forth from being either too large or too small as circumstances in the fusion community changed.*"

"*Inclusion of papers on "cold fusion" (or anomalous nuclear reactions in solids) in FT has been one of the more controversial decisions I made as editor of FT. Rather than rehash the issues involved, I would simply repeat my view expressed in an early preface that it is the "responsibility of a journal to publish scientific work related to its field of coverage that can pass through peer reviews." Indeed, all papers on this topic in FT have undergone a rigorous peer review. In the early years (1987- 1990) following Pons and Fleischmann's original announcement, reviewers ensured that the papers were technically sound but allowed speculations about mechanisms since the field was so new. However, starting in 1990, as the field matured, review standards reverted to the same guidelines as other papers in FT. Further, based on discussions in the FT Editorial Advisory Committee, an additional reviewer from outside the "cold fusion community" was typically added on these manuscripts. Readers who are interested in more detail about events during this period from my point of view as an editor are referred to an article titled "Some Personal Reflections on Scientific Ethics and the Cold Fusion 'Episode'" that I prepared for a fall issue of the Journal on Accountability in Research' Policies and Quality Assurance, Vol. 8, No. 1 (2000).*"[Miley 2000a]

[Miley 2000a] G.H. Miley, "As an Editor of the Fusion Technology," *Fusion Technology*, 38, iii (November 2000), ISSN 0748-1896.

Appendix G – Main International Conferences on the Cold Fusion Phenomenon until 2010

In the early days of the CFP research, there have been scheduled Conferences where were presented papers on the CFP. However, after the publication of the DOE Report in December of 1989, papers on the CFP had been published in limitted periodicals, such as *Futions Technology* and *J. Electroanalytical Chemistry*, and presented at International Conferences scheduled for the CFP. To show the main stream of the International Conferences, a brief data of the main International Conferences on the CFP is given in Fig. E1 in addition to the periodicals in the same period.

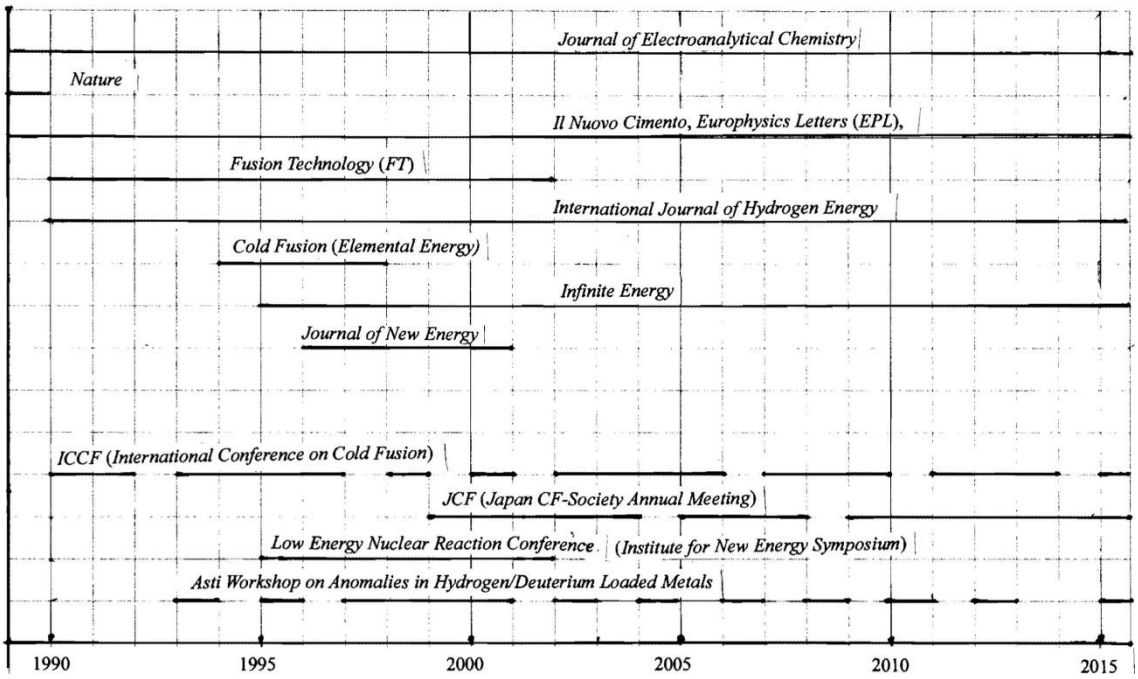

Fig. G1 Periodicals and International Conferences on the Cold Fusion Phenomenon until 2015

Appendix H – Funding Organizations for the CFP

The funding organizations on the cold fusion research have been various depending on the country and time after the discovery in 1989. This is a big theme to be discussed in a large monograph. We give here an incomplete list of organizations which have supported the CFP mainly in the early times of the history of the CF research. The economic system differs from a country to another and the list is given in main countries where have been specific organizations in addition to governmental ones.

There had appeared following funding organizations in the initial period of the history of researches on the cold fusion phenomenon as we have given in Appendix E;
DOE (Department of Energy, USA)
NSF (National Science Foundation)

Then, after 1989, there had been many organizations which supported Conferences on the CFP and Individuals. We cite typical **"Organizations sponsored ICCF" (A)** and **"Organizations supported Individual Researchers" (B)** below by countries where researches on the CFP have been performed vividly.

H1. USA:

AEP (the Office of Advanced Energy Projects at DOE); (cf. Appendix H5-2).

CFRI (Cold Fusion Research Institute) (A, B); Sponsored ICCF2 (June 29 – July 4, 1991).
DARPA (the Defense Advanced Research Projects Agency); (cf. Appendix H5-3).
EPRI (Electric Power Research Institute) (A); Sponsored ICCF2 (June 29 – July 4, 1991) and ICCF4 (Dec. 6 – 9, 1993). EPRI published a complete set of papers submitted to ICCF4 (4th International Conference on Cold Fusion held December 6 – 9, 1993, at Lahaina, Maui) as EPRI Report TR-104088, Volumes 1 through 4, which are available through the EPRI Report Distribution Center.
New York Community Trust (B); Supported several researchers for many years.
ONR (Office of Naval Research); (cf. Appendix H5-1).
SRI (Stanford Research Institute) (A, B); Many excellent works have been performed and published. One of the excellent works was the paper "Excess Power Observed in Electrochemical Studies of the D/Pd System," *Proc. ICCF3*, pp. 5 – 19 (1993).

Characterization of some organizations is given by G. Taubes in his book [Taubes 1993]. Some sentences have been reproduced in Appendix H5 below which will give more information about the organization than the formal description.

H2. JAPAN:
AISHIN SEIKI Co. Ltd. (A); Sponsored ICCF5 (April 9 – 13, 1995).
IMRA (Europe) (A, B); a company in the AISIN group; Published Proceedings of ICCF5 (April 9 – 13, 1995).
JSPS (Japan Society for the Promotion of Science) **(A, B)**; Sponsored ICCF3 (October 21 – 25, 1992). JSPS distributes funds for researchers in all scientific fields including CFP through "Grants-in-Aid for Scientific Research."
NEDO (New Energy and Industrial Technology Development Organization) in **MITI** (Ministry of International Trade and Industry, Japan) **(A);** Sponsored ICCF6 (October 13 – 18, 1996).
TECHOVA (Technova Corporation) (A, B); Sponsored ICCF2 (June 29 – July 4, 1991) and ICCF5 (April 9 – 13, 1995). Also it is supporting several researchers on the CFP.
TEET (The Thermal & Electric Energy Technology Inc. Foundation) (A, B); Sponsor of JCF(Japan CF-Research Society) website. Funding researchers in energy-related fields including CFP.

H3. ITALY:
ENEA (Italian National Agency for New Technologies, Energy and Sustainable

Economic Development) (A);

FIAT; A sponsor of the ASTI Meeting held in Italy almost bi-annually as seen in Fig. G1 (cf. Appendix G).

"Four years ago Fiat, the automobile group, (and other sponsors) invited a group of nearly 20 international experts in Cold Fusion to a private meeting at Villa Riccardi, near Asti." (W.J.M.F. Collis, "Asti Workshop on Anomalies in Hydrogen / Deuterium Loaded Metals November 27-30, 1997 in Asti, Asti Province, Italy" *Infinite Energy,* December 1997-January 1998 (#17))

Italian Physical Society (A); Published *Proceedings of ICCF2* and *ICCF8*.

H4. Other Countries

ENECO Inc. (one of the largest producers and suppliers of natural gas, electricity and heat in the Netherlands, serving more than 2 million business and residential customers.); Sponsored ICCF5.

BARC (The Bhabha Atomic Research Centre, India), India's premier nuclear research facility based in Trombay, Mumbai, Maharashtra. BARC is a multi-disciplinary research centre with extensive infrastructure for advanced research and development covering the entire spectrum of nuclear science, engineering and related areas; have given many contributions on the CFP from the initial period. The paper "Overview of BARC Studies in Cold Fusion,**"** *Proc. ICCF1* (March 28 – 31, 1990. University of Utah Research Park, Salt Lake City, Utah: National Cold Fusion Institute), pp. 62 – 81 (1990) was a splendid work at this time.

H5. Characterization of Organizations by G. Taubes.

Following sentences from G. Taubes [Taubes 1993] show us a characteristic situation of scientific researches in a society of the state capitalism (or the state controlled financial capitalism).

H5-1 ONR (Office of Naval Research)

"*Once Stan Pons submitted his proposal to his benefactors at the* ***Office of Naval Research,*** *the cold fusion affair took on an aura of inevitability. Although ONR had a reputation for funding speculative research projects, either Pons or Robert Nowak, his funding officer, decided that ONR was not the right place for cold fusion. Pons told Hugo Rossi that he feared the Department of Defense, of which ONR was a part, might classify cold fusion. They might realize the potential military uses of an invention that, if it wasn't a hydrogen bomb itself, would still produce tritium, a necessary and valuable*

component of hydrogen bombs." [Taubes 1993 (p. 19)]

H5-2 AEP (the Office of Advanced Energy Projects at DOE)

"*Since Pons preferred to think of cold fusion as an energy source, not a weapon, he sent the proposal to his friend Jerry Smith, a funding agent in the Department of Energy's physical chemistry program. At one time Smith had been program manager for Pons submitted his proposal to the Office of Advanced Energy Projects at DOE, run by an administrator name Ryszard Gajewski (pronounced Richard Guy-EV-ski).*" [Taubes 1993 (p. 20)]

"*The office had been inaugurated in 1977 to do for the Department of Energy* (what the Office of Naval Research and the Defense Advanced Research Projects Agency did for the Pentagon.) *The Office of Advanced Energy Projects would support the kind of speculative ideas that might not pass peer review in the conventional programs but if given a glimmer of a chance might pan out—in other words, long shots. In particular, AEP supported exploratory research on power and energy projects that didn't fit into any of the other pigeonholes of the DOE's Basic Energy Sciences Division. The division had a yearly budget of $10 million and a professional staff of one—Ryszard Gajewski.*" [Taubes 1993 (p. 20)]

H5-3 DARPA (the Defense Advanced Research Projects Agency)

"The office had been inaugurated in 1977 to do for the Department of Energy what the Office of Naval Research and *the Defense Advanced Research Projects Agency did for the Pentagon.* The Office of Advanced Research Projects would support the kind of speculative ideas that might not pass peer review in the conventional programs but if given a glimmer of a chance might pan out – in other words, long shots." [Taubes 1993 (p. 20)]

"Jones had just published a paper with Clinton Van Siclen of the Idaho National Engineering Laboratory on piezonuclear fusion—Jones's term for fusion induced by extraordinary pressure rather than extraordinary high temperatures." [Taubes 1993 (p. 26)]

"And, if he was then planning to use electrolysis, to condense deuterium in a metal and induce fusion, as he would claim later, he never actually wrote down the word electrolysis." [Taubes 1993 (p. 27)]

“On May 13, 1986, Jones submitted his annual progress report on muon-catalyzed fusion to Gajewski and included notes on the piezonuclear fusion ideas. Gajewski, in return, gave Jones the go-ahead to spend a share of his muon-catalyzed fusion money on . piezonuclear fusion experiments.” [Taubes 1993 (p. 27)]

“This may have been an unfortunate commentary on the value of the 1989 data, because Czirr, who had been building and using detectors for thirty years, said the 1986 data, were ‘nothing worth mentioning’ and contained ‘no real hint of anything.’” [Taubes 1993 (p. 29)]

“They could only procure funding in America from Gajewski, and he could only provide it so long as commercial fusion appeared to be close to the next corner. That was the institutional condition of his support.” [Taubes 1993 (p. 32)]

“In September 1987, two months after the Scientific American article appeared, Gajewski managed to get Jones two more years of support at $208,000 per year. And in March 1988, six months after Rafelski began at the University of Arizona,11 Gajewski awarded him over $975,000 for three years to do "energy related applications of particle theory." It was an extraordinarily large grant for a theorist.” [Taubes 1993 (p. 33)]

“In any case, before Jones could compose his own proposal to study piezonuclear fusion, Gajewski sent both him and Rafelski a proposal to review entitled "The Behavior of Electrochemically Compressed Hydrogen and Deuterium," by B. Stanley Pons and Martin Fleischmann.” [Taubes 1993 (p. 35)]

“However, when presented with the facts that noting was done on the subject for twenty-nine days after the meeting and that he had reviewed the Pons-Fleischmann proposal by then, Jones insisted that this level of activity still legitimately meets the definition of "vigorous pursuit." He did not deny that he may have had "impetus" from the Pons-Fleischmann proposal but argued that Pons and Fleischmann had not accused him of "impetus"—they had accused him of stealing ideas wholesale. Jones conceded that perhaps in drafting BYU's official account he should have noted that he had assigned a student to do electrolysis experiments (of the kind Paul Palmer had pursued two years earlier and Pons and Fleischmann were now proposing) only after reading the Utah proposal.” [Taubes 1993 (pp. 36 – 37)]

“Whether he did or not was important merely because Pons and Fleischmann believed that Jones only "vigorously" began his research after reading their proposal, and that the fate of billions of dollars, among other things, hinged on whether he did or not. And what Pons and Fleischmann believed, rightly or wrongly, was what led them publicly and emphatically to disclose their invention on March 23, which is to say well before they had gathered sufficient data to support their claim.” [Taubes 1993 (p. 37)]

“The abstract that Jones had submitted to the American Physical Society, even with two meager sentences on cold fusion, might constitute a public disclosure once it appeared in print. It was scheduled for the first week of April. That became the deadline for whatever had to be done, which gave the U roughly three weeks. The option of having Pons unveil cold fusion at the American Chemical Society meeting in the second week of April was no longer viable. Jones's APS abstract would appear a week before the meeting.” [Taubes 1993 (p. 96)]

“Either way, Fleischmann certainly was the most prescient about the ugliness of the deluge that would follow a news conference. And afterward it was Fleischmann who would lay the entire responsibility for the decision and the subsequent circus on the U administration. "That was the decision of the university," he said. "You can read into that anything you want." Nonetheless, at that point, Pons and Fleischmann still could have put a stop to the affair. They did not.” [Taubes 1993 (p. 97)]

“Hawkins had also taken Fleischmann to the airport, where he caught a flight back to England. According to Ron Fawcett, Fleischmann took a revised version of the JEAC paper with him on the plane. Apparently Pons also faxed a copy of the paper to Parsons in Southampton on the twenty-second, because when *JEAC* published the Pons-Fleischmann paper [Fleischmann 1989], it said that it had been received in "revised form," on March 22. Either way, this conveniently put it one day before *Nature* received the BYU manuscript [Jones 1989].” [Taubes 1993 (Notes p. 440)] ([Fleischmann 1989] and [Jones 1989] in this quotation are added at citation and *JEAC = J. Electroanalytical Chemistry*).

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