BOOK REVIEW

Selection of books for review is based on the editor's opinions regarding possible reader interest and on the availability of the book to the editor. Occasional selections may include books on topics somewhat peripheral to the subject matter ordinarily considered acceptable.

Too Hot to Handle: The Race for Cold Fusion

Author	Frank Close
Publisher	Princeton University Press, Princeton, New Jersey (1991)
Pages	376
Price	$24.95
Reviewer	William C. Gough

INTRODUCTION

I found this book exciting, but this may be because I approached the book as a scientific mystery story. I suggest that you will also have more fun reading the book if you treat it as a mystery story and look for clues. The book is written for the general scientific audience and communicates quite successfully at this level. It is well documented and maintains a high level of technical accuracy on scientific details. Regarding organization, I found the book to be a logical presentation on a subject I was curious about and eager to explore. Its major organizational drawback is its annoying repetitiveness.

THEMES IN THE BOOK

The author makes worthwhile and important distinctions in terms of the scientific research on (a) magnetic and laser hot fusion, (b) muon cold fusion such as the work by Steven Jones of Brigham Young University, and (c) solid-state cold fusion as initially reported by Fleischmann and Pons. The book is an analysis of the latter phenomenon. Certain themes run throughout the book. The first is that data, not theory, should be the basis of science. With this I wholeheartedly agree! The second is that reproducibility of an experiment is required if the effects are genuine. Here I believe we must be very careful because our existing theories may blind us to unsuspected variables. The third theme in the book is more *implied* than explicitly stated. I came away from the book with the feeling that the author really believes the scientist he quotes on p. 147 who said, "If it's not physics and it's not chemistry then it's not happening!"—where physics seemed to be interpreted as our current understanding of nuclear processes.

BELIEF SYSTEMS AND PEER REVIEW

The author recognizes the powerful effect that belief systems can have on scientists, as his following quote illustrates: "It is a well-known trait of human psychology that people can become so committed to a preconceived belief in something that contrary information is ignored or reinterpreted to fit with the 'facts'" (p. 345). However, in the book, the author attributes this trait only to those scientists working on cold fusion. In my opinion, this human trait should be considered as a factor influencing actions and opinions throughout the entire scientific community.

For example, I am a strong supporter of the peer review process and have used it extensively for >30 yr in the funding of research in both the government and private sectors. However, there are pitfalls to the peer review process that the author does not admit. The key weakness in the peer review process is that the greater the change in belief system that may be required of the peer reviewer by the data, the more difficult a "fair" review becomes. Cold fusion experiments appear to require an open belief system on the part of the reviewers and are therefore particularly vulnerable to technically sound, but "unfair," peer reviews. Every sophisticated funder of research knows that you can "kill" a proposal by inappropriate choice of reviewers—not because the reviewers lack detailed technical knowledge but because of their limited belief system of what may be possible. The feat becomes finding highly qualified scientists who can expand their existing belief system, recognize "key" data, and review on the basis of the quality of the data and the adequacy of the experimental procedures.

THE BEHAVIOR OF SCIENTISTS

As I read this book I felt compassion for Fleischmann and Pons because of the situation in which they found themselves. The author also appears to share some of this view.

He notes that "Fleischmann and Pons believed strongly in their results," and he recognizes that they were "under intense pressure month after month" (p. 327). However, the impression gained from reading the book was more judgmental than I considered warranted. From one perspective, we could agree with the author and say that Fleischmann and Pons "from time to time reacted irrationally while in the glare of media attention" (p. 327). Nevertheless, the proper behavior of scientists projected by the author appears more idealistic than my long experience as a funder of research would support. Scientists are human beings; they react to the possibilities of fame, money, attention, and criticism and to the fear of being cheated. They take protective actions and follow the advice of lawyers and administrators. In the saga of cold fusion, unfortunately all these factors were present at once and in unusually large quantities. Thus, I found the actions of Fleischmann and Pons to be very unfortunate but understandable—I am sure they are wiser men today and would do things differently if faced with the same situation again.

POSSIBLE CULPRITS

Now let us look at the "mystery" of cold fusion. As the investigation into cold fusion proceeds throughout the book, a series of possible "suspects" for the reported results from cold fusion are mentioned. Some are agreed to be innocent from the start, some are investigated in detail and, at times, in excruciating detail, and some are all but ignored. The possible suspects that I found mentioned in the book are listed and then explored in turn:

1. a nuclear fusion reaction
2. a chemical reaction
3. experimental error
4. new physics in the current scientific paradigm or beyond.

Nuclear Fusion

Nuclear fusion is the prime suspect under investigation in the book, and it appears to be the author's goal to prove this suspect innocent beyond a shadow of a doubt. Yet, if the Fleischmann and Pons results were due to our current understanding of nuclear fusion, the author states that you would "find that there should be a thousand billion neutrons pouring out of the apparatus each second!" Since there was no protective shielding, this "would be a lethal dose many times over," and the researchers should be dead (p. 126). Nevertheless, most of the book, in the author's words, is "concentrated on the evidence for fusion, or rather, the lack of it" (p. 259).

Chemistry

This suspect appears to be considered innocent from the start. If the Fleischmann and Pons results were due to chemistry, then "the overall heat output claimed by them implied that each individual atom was putting out at least one hundred times as much energy as would be possible if chemical processes alone were at work." Thus, "the scale of output appeared utterly beyond that of chemistry." Fleischmann and Pons and the author agree on this. However, there may be a caveat based on the volume assumed when calculating the energy density, and this may be why the author suggests a new look at this suspect in his conclusion.

Experimental Error

This is a chief suspect for the author. The author does an excellent job of highlighting the experimental pitfalls in cold fusion research. For example, he points out the problem of open versus closed cells, the issues associated with tritium and helium impurities and contamination (pp. 141 and 249), the sensitivity of the neutron detectors to temperature when used at low levels of radiation (p. 144) as well as to "remote happenings" and "noise," the potential importance of stored energy from crystalline structural changes in palladium due to stress and strain (p. 245), the difficulty of measuring effects at the borderline of detectability (p. 254), and so forth. He also focuses great attention on the error in the location of the nuclear data signal peak as originally reported by Fleischmann and Pons as evidence of sloppy science. The author has thus cast doubt on many of the initial claims of cold fusion researchers and made a strong case for greater care and attention to details by both chemists and physicists in this interdisciplinary field. However, he never seems to have enough evidence to indict the subject; there always appears to be another alibi.

New Physics in the Current Scientific Paradigm or Beyond

The author recognizes that the "culprit" may not have been found as yet and investigates a few suspects under this category, e.g., the possibility of proton-deuterium fusion. The investigation of this category of suspects appears rather incomplete. I feel that there must be a greater number of potential theories and possibilities to be explored. Some of these could even be outside our current scientific paradigm. The author recognizes this when he quotes a statement by Culham Laboratory fusion experts that one of the explanations for the observations could be that "some entirely new and unexpected phenomenon had been uncovered." Since very little attention is given to this possibility in the book, I began to look for "clues" to see if more suspects just might exist.

As evidence that the culprit may still be at large, the author states that there is still "the tantalizing possibility that the heat (or more precisely the power) input from the electricity supply and that measured from the cell do not balance—some groups insist that there is 'excess' power" (p. 259). He also mentions that "there have been reports of large bursts, with temperature rises of tens of degrees—even boiling the electrolyte. These seem to be too big to be dismissed as calibration errors" (p. 263). The author notes that these bursts were described by the U.S. Department of Energy (DOE) review as "mysterious and perplexing."

One clue could be the author's statements about the claims from Fleischmann and Pons, as well as from other research groups, that there has been heat produced from cells fueled using "ordinary water." Since heat cannot be produced from ordinary water in any conventional fusion process, the author considers this a "damaging result." In the author's words, "the conclusion from this ought to have been either that something was wrong with the calorimetry, or that the heat is not produced by a nuclear process" (p. 296). My reaction to such claims is different. I would not draw a conclusion but would consider the observation interesting and actively seek an evaluation of possible errors in the data from

the different laboratories. If such data continued to appear under credible experimentation, then it could represent an important clue that a new and interesting process was involved.

Another possible clue is the author's report that levels of tritium "too high to be dismissed as an error of measurement" are "being produced with no energy" (pp. 269-270). The author writes this data off by stating that the tritium is "almost certainly a contamination" and "has not been produced by a nuclear reaction within the experiment" (p. 271). The probabilities are that the author may be right, but he may also be wrong. There are even known mechanisms such as superasymmetric fission that result in a restructuring of an atomic nucleus and cause the release of clusters of nucleons. If this was happening, one could find unexpected elements, including tritium and helium, in the anode, cathode, or electrolyte.

There may be other, more subtle, clues. Are the observed surface effects something we completely understand, or could they be a clue that nuclear properties are not uniform or can be affected in some way? Are the sporadic *destructive* bursts of energy really just chemical explosions, or are they a clue to the tapping of energy from an unexpected source, e.g., the quantum vacuum? I put forth these speculations not because I necessarily believe that they will be proven correct but rather to stimulate a more open approach to our thinking regarding cold fusion. To me, the lack of openness to the possibility of the unexpected represents the greatest danger facing our country's leadership in world scientific research.

Reproducibility

Last but not least, one of the most interesting clues, continually emphasized by the author, is the fact that nonreproducibility appears to be a consistent characteristic of current cold fusion experiments. Although cold fusion results seem to be repeatable in a given laboratory, no laboratory appears to have achieved *consistent* reproducibility on demand. There are always cells that get no effect at all. This situation has been reported in a number of laboratories in this country and around the world. The author quotes the DOE review panel as saying, "The claims of cold fusion, however, are unusual in that even the strongest proponents of cold fusion assert that the experiments, for unknown reasons, are not consistent and reproducible at the present time" (p. 252). He also quotes the Euratom interim report as saying, "There is no doubt that irreproducibility is the bane of these phenomena" (p. 253).

The author appears to have drawn a conclusion from these facts of nonreproducibility that may not be warranted. Throughout the book, an implied assumption is made that cold fusion cannot be real if it is not possible to achieve *consistent* reproducibility. In the author's words, "Here again one has the non-reproducibility aspect, the failure of an essential precondition for a sure, scientifically acceptable, result" (p. 249). Consistent reproducibility is not an absolute law of nature, just a convenient tenet used in the physical sciences. This tenet arises because of our assumption that space-time forms a closed manifold. This assumption of a closed space-time system permits the demand for consistent reproducibility, which has been found to work for essentially all physical systems. However, quantum fluctuations occurring at the Planck scale are believed to affect the topology of space-time. Thus, many scientists think that space-time is not smooth but foamy, more like a sponge. Hence, the tenet of consistent reproducibility is not on the solid ground assumed by the author.

We all know that in the biological and human sciences that deal with living systems, we must include the possibility of effects due to the observer's mind. That is the reason for the elaborate double-blind experimental protocols used in such experimentation. We also should be aware that in quantum mechanics there is no sharp boundary between where the observer effect begins and where it stops, only an "agreed-upon interpretation" of the theory. Thus, the boundary can shift and does, depending on the belief system of the scientist and his or her area of expertise. This issue can be readily explored by reading the literature on quantum gravity, quantum cosmology, macroscopic quantum effects, and the nonlocality argument in the experimental tests of Bell's theorem.

We also know that chaotic processes abound in nature. Chaos provides a way of seeing order and pattern where formerly only the random, the erratic, and the unpredictable had been observed. All chaotic systems are extremely sensitive to very slight changes in initial conditions. Could cold fusion involve a chaotic process that is extremely sensitive to initial conditions? Could the triggering of this process even include a component due to a "coupling coefficient" between the conscious/unconscious minds of the observer/experimenters? Could there exist physical science experiments with "nonliving" matter where a double-blind protocol is needed?

CONCLUSION

In this "mystery story," the principal suspect, nuclear fusion, is judged to be innocent, and a finger is pointed to another suspect. In the conclusion of the book, Frank Close implies that the culprit could be "an interesting effect in the electrochemistry of palladium" (p. 341). For this reviewer, the "ending" represents a very unconvincing conclusion to this exciting mystery story. One cannot help but feel that the true culprit has yet to be found. I came away from the book wondering if the "murderer" was "someone" who, because of our entrenched beliefs and resulting blindness, we have not yet even considered as a suspect. In fact, the culprit in this strange case of the "cold fusion murder" might even include us (our minds) as an accomplice.

The major weakness in *Too Hot to Handle* is that the book does not encourage one to look deeply into the assumptions underlying our current scientific beliefs. All scientific theories impose a set of constraints or boundaries on our thinking. Yet the theories are essential since they tell us what to look for in an experiment, and we must know what we are looking for before we can see it. Without a theory, data would fly by unnoticed. This book convinced me that the explanation for the phenomenon that has been called "cold fusion" has yet to be discovered. It remains an experimental area *without* a theory, and one wonders just how much data is flying by unnoticed!

Cold fusion may eventually disappear from the scientific spectrum as errors in the experimental methodology and data are revealed. This is the author's belief, and the history of science says that he is probably right. However, if the anomalies persist, there exists the possibility that cold fusion may turn out to be more than just another small step along our current scientific path. Cold fusion could be the precursor that leads to a quite radical change in belief for the physical sciences. Any such potential change in belief should be carefully scrutinized and approached with caution. Therefore, I *strongly* support the position taken by the author throughout

the book that those engaged in such research respond in full to the technical objections to their data, experimental procedures, or protocols.

This process will not be easy. Hence, I encourage those working in cold fusion to have the courage to follow their convictions and inner guidance. I encourage those funding such research not to succumb to group pressure or concerns about ridicule but to carefully review the validity of data and provide the funding to seek answers to remaining questions. Finally, I encourage the scientific community to recognize that our current science is based on assumptions, some hidden, and that we should not fear the possibility that nature may give us evidence that could require a major change in those assumptions. Rather, we should all encourage this quest into the unknown.

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