Report of the Investigation Committee
In the Matter of Dr. Rusi P. Taleyarkhan

Prologue

The Purdue University Investigation Committee in the Matter of Dr. Taleyarkhan was appointed under Executive Memorandum No. C-22 (Policy on Integrity in Research) by Interim Provost Victor L. Lechtenberg, Dean of Engineering Leah Jamieson, and David Williams, the Chairperson of the Faculty Affairs Committee of the Purdue University Faculty Senate. The Committee received its charge on November 1, 2007. The Committee also received a concurrent charge under the research misconduct procedural guidelines used by the Office of Naval Research ("ONR").

From the outset, we the committee members were aware of the public controversies surrounding this case. In addition, we fully appreciate the importance, if true, of the science of sonofusion reported by Dr. Taleyarkhan, whether or not future practical applications of the technology are forthcoming. We recognize the press and public focus on prospects of a cheap, unlimited energy source. The scientists involved are cognizant of this focus and are susceptible themselves to enthusiasm and hope for that long-term goal. However, the task of the committee was not to judge the validity of the particular experimental results, but to assess specific charges of misconduct.

Our investigation has given us a glimpse of human and institutional failings. Neither the participants nor this committee understand all its dimensions, but all who have some familiarity know the extraordinary stress that has been placed on accomplished individuals, an important research department, and a great University. From small beginnings there developed a tangled web of wishful thinking, scientific misjudgment, institutional lapses, and human failings. Each strand could have been resolved separately, but knitting them together produced a crisis. The broader issues that have emerged bear upon the interactions between science and government, the public communication of science, and ultimately, the integrity of the research process itself.

Absolute honesty and transparency are essential ingredients of science. Without full confidence in the integrity of the information provided in publications, research seminars and communications with the general public, the validity of the results cannot be judged by peers or society at large. In scientific communication this applies to the description of all relevant aspects of experiments, to the statement of experimental results, and to the descriptions of the treatment and analyses of the data. It also applies to the authors listed as the researchers responsible for the result. The latter is especially important in a "confirmatory" measurement since *reproducibility* by *independent* experiments and researchers is a key component of the scientific method.

Procedural History

The inquiry and investigation processes under Executive Memorandum C-22 have been exhaustively followed by the Inquiry Committee and the Investigation Committee. Both committees have been staffed by distinguished scientists and have gathered and analyzed huge volumes of evidence and testimony. The Investigation Committee consisted of Dr. Mark Hermodson, Chair (Purdue University), Dr. Mary Ellen Bock (Purdue University), Dr. Charles Kennel (University of California, San Diego), Dr. James Kolata (University of Notre Dame), Dr. Don Miller (The Ohio State University), and Dr. John Schiffer (Argonne National Laboratory).

The Investigation Committee received the August 27, 2007 report of the Purdue University C-22 Inquiry Committee regarding the allegations submitted to the University in the first half of 2007 from both internal and external sources. The Inquiry Committee forwarded multiple allegations of potential misconduct to our committee, all of them involving allegations of either falsification of the scientific record or plagiarism.

In addition to the large volume of evidence assembled by the Inquiry Committee, we also had access to additional evidence submitted directly to our Committee between December 2007 and April 2008.

From February 1 to 3, 2008, we heard live testimony from Emil Venere, Jeanne Norberg, Yiban Xu, Shripad Revankar, Adam Butt, Lefteri Tsoukalas, Rusi Taleyarkhan, Joshua Walter, Colin West, Robert Block, Robert Nigmatulin, and two staff members in the Purdue School of Nuclear Engineering. We considered written testimony from Shripad Revankar, Richard T. Lahey, Colin West, Robert Block, Robert Nigmatulin, Edward Forringer, Günter Lohnert, William Bugg, Jaeseon Cho, and three members of the staff in the Purdue School of Nuclear Engineering.

In response to a draft of this report, Dr. Taleyarkhan submitted rebuttal contentions and commentary, which we considered.

Legal Standards

Purdue's C-22 policy and the ONR process for handling Research Misconduct Allegations instruct us to decide each allegation by a preponderance of the evidence.

Under the C-22 policy, falsification can occur in either the conduct or reporting of research. The ONR process instructs that research misconduct can occur in conducting, proposing, reporting, or reviewing of research. Falsification is an intentional act. Therefore, to conclude that research misconduct-by-falsification has occurred, we must find that the respondent intended to falsify and did falsify information in the conduct, proposing, reporting, or reviewing of research, according to a preponderance of the evidence.

We have also taken guidance from The American Physical Society on the subject of scientific authorship standards.

The C-22 policy requires us to make findings on "each fact necessary to establish that the accused committed research misconduct." Therefore, our discussion below includes findings of fact organized by allegation.

Executive Summary

The Inquiry Committee forwarded twelve allegations. For the sake of clarity, the Investigation Committee (hereafter "Committee") has aggregated and restated some of the allegations, while cross-referencing the underlying Inquiry Committee numeration of those allegations. Several of the allegations are related to actions connected with publication of a set of measurements, and it is not possible to separate them completely with respect to the overall question of a pattern of action that constitutes misconduct. But because of the requirements of the C-22 procedure, we make separate conclusions for each allegation.

Allegation A.1

Dr. Taleyarkhan with falsifying intent caused his name not to be included in the author bylines of the NED and NURETH-11 papers to disguise the extent of his involvement in the execution of the work reported and in the writing and submission of the papers.

Conclusion

Even though a large volume of evidence clearly shows that Dr. Taleyarkhan was heavily involved in every aspect of the research and publication of the manuscripts, the Committee concludes that there are a number of reasons why a senior mentor's name may not appear as an author of a publication. Thus we cannot unequivocally deem the omission of his name as an intentional act of falsification of the author byline.

Allegation A.2

Dr. Taleyarkhan with falsifying intent caused Mr. Adam Butt's name to be added to the author bylines of the papers even though Mr. Butt was not a significant contributor to the experiments, the data analyses, or the writing of the manuscripts.

Conclusion

The Committee concludes that the weight of the evidence shows that Dr. Taleyarkhan compelled the addition of Mr. Butt's name as an author on the NED and NURETH-11 publications knowing that Mr. Butt had not substantively contributed to those publications in order to create an appearance of collaboration between Dr. Xu and Mr. Butt on the work. This is research misconduct.

Allegation B.1

Dr. Taleyarkhan with falsifying intent caused the July 12, 2005, press release from Purdue University to give credit for sponsorship and direction of the work to be published in the NED and NURETH-11 papers to Dr. Tsoukalas and to leave the impression in the press release that there was a high degree of independence of Dr. Xu and Mr. Butt from

Dr. Taleyarkhan's laboratory and direction.

Conclusion

While the findings for this section bear heavily on the conclusions of the next section, the Committee concludes that the information in the press release is true in a technical sense, even though it is crafted in a very misleading way. It is also not clear that a press release is part of the scientific record, being aimed at the general public. Thus, we conclude that the manipulation of the press release does not constitute research misconduct.

Allegation B.2

Dr. Taleyarkhan with falsifying intent stated in the opening paragraph of his paper in Physical Review Letters **96**:034301 (2006) that "these observations [referring to Science **295**:1868 (2002)] have now been independently confirmed."

Conclusion

Based on the findings in this section and in the preceding sections, we find that Dr. Taleyarkhan's claims of independent confirmation of his sonofusion results are simply not supported by the weight of the evidence of his extensive involvement in the NED and NURETH-11 research and publication. The direct assertion of independent confirmation in the PRL**96** paper is falsification of the research record and thus is research misconduct.

Allegation C

Dr. Taleyarkhan with falsifying intent used identical calibration data in the NED and NURETH-11 papers and in his publication in Multiphase Science and Technology **17:** 191-224 (2005), implying that the data refer to the same experiment.

Conclusion

All of the authors agreed to the data sharing. The MST publication is a review article, which would allow reproduction of previously published work. While copyright laws were flouted, the Committee does not find research misconduct in this allegation.

Allegation D

In his publication in Multiphase Science and Technology **17**:191-224 (2005), Dr. Taleyarkhan with falsifying intent attempted to make it appear that the same results were the outcomes of several experiments by re-publishing previously published data without citing the original publications.

Conclusion

Again, the authors all agreed to the sharing of data, and its repetition in both the NURETH-11 and MST papers is in keeping with the review nature of the papers. The flouting of copyright laws is certainly a serious inattention to details, but no allegations of plagiarism have come from the authors whose data were reproduced. Thus, we do not find research misconduct for this allegation.

Allegation E

Dr. Taleyarkhan used federal funds for the work published in Physical Review Letters **96**:034301 (2006) [PRL **96**] and failed to acknowledge support of the agency in the publication.

Conclusion

It is clear from the salary records that Dr. Taleyarkhan was, in fact, paid from DARPA funds during the time the manuscript was written. For that reason federal funding should have been acknowledged. However, we lack evidence that Dr. Taleyarkhan possessed a falsifying intent for that omission. Therefore, we do not find research misconduct for this allegation.

Allegation F

In his published response to a forensic analysis by Dr. Brian Naranjo in Physical Review Letters (PRL) **97**:149404, Dr. Taleyarkhan claims to show the same fusion data but, allegedly, actually deleted some of his originally published research results.

Conclusion

The Committee concludes that the omission of one data point was scientifically defensible and thus not an instance of research misconduct.

Allegation G

Dr. Taleyarkhan falsified a September 19, 2003 fusion demonstration carried out at Purdue by him and Dr. Cho of Oak Ridge National Laboratory.

Conclusion

The Committee finds that the evidence in this matter does not support a conclusion of research misconduct.

Overall Summary

The Committee finds that the weight of the evidence supports findings of research misconduct for Allegations A.2 and B.2. Our findings and conclusions for each individual allegation follow below.

A. Allegations relating to NED and NURETH-11 publications [IqC allegations C2, D2]

The Inquiry Committee forwarded several allegations regarding authorship of two closely related papers with Dr. Xu as lead author: Nuclear Engineering and Design **235**:1317-1324 (2005) [hereafter called NED] and the NURETH-11 Conference Proceedings in October, 2005.

1. **Allegation:** Dr. Taleyarkhan with falsifying intent caused his name not to be included in the author bylines of the NED and NURETH-11 papers to disguise the extent of his involvement in the execution of the work reported and in the writing and submission of the papers.

We make the following findings of fact regarding this allegation.

FF1. Dr. Xu conducted the reported experiments from January to May 2004, with supplemental work later. According to Dr. Xu, he "became full-time under the direction of Taleyarkhan" once Dr. Xu completed his thesis defense in February 2004.[1]

FF2. Dr. Xu stated "the observations and analysis work were completely done by me and my colleagues, not by Dr. Taleyarkhan."[2] According to Dr. Xu, Dr. Taleyarkhan provided the test cell, provided instructions on its operation, gave advice on the experiment, and sometimes was "present during actual experimentation" for the data presented in the NED and NURETH manuscripts.[3] According to Dr. Taleyarkhan, he helped Dr. Xu "clarify" what "operational aspects of the bubble dynamics may lead to null results."[4]

FF3. Dr. Revankar had minimal involvement in the experiment.[5] Dr. Revankar checked the counting data and the analyses of the data, and ultimately presented the work at the NURETH-11 conference. His testimony was consistent with Dr. Xu's testimony that Dr. Xu was the person who did the data acquisition.[6]

FF4. The manuscript that ultimately appeared in NED was initially submitted to the journal Science on or about October 15, 2004. This manuscript underwent numerous revisions over a period of months as the targeted journal changed from Science, to Physical Review Letters, until finally it

was published in NED.

FF5. The earliest draft of the Science manuscript in electronic form is from Dr. Xu entitled Outline_2.doc. It was created on October 12, 2004 at 5:27 p.m., revision number 2, and was last saved by Dr. Xu. Revision number 3 was created on October 14, 2004 at 6:03 p.m. and was last saved by Dr. Taleyarkhan. The difference between the October 12 and October 14 manuscripts is considerable, both in terms of the grammar and in the scientific content, suggesting that we may not have received all of the drafts.

FF6. After rejection by Science, the manuscript was quickly submitted to Physical Review Letters on or about October 21, 2004. In both instances, Dr. Xu was the sole author, with Joshua Walter and others receiving an acknowledgement.

FF7. While it is not clear who wrote the very first draft of the paper for Science, there ***is*** a great deal of evidence showing that there were editing and substantive changes made to the manuscript by Dr. Taleyarkhan.[7] In an email and its attachment, dated December 16, 2004: 6:31 p.m., from Dr. Taleyarkhan to Dr. Xu, Dr. Taleyarkhan added detailed numerical information to Figure 5 and elsewhere in the text.[8] Dr. Taleyarkhan made an addition to the text in Figure 5 involving a numerical calculation to convey the statistical significance of the cavitation-on versus cavitation-off signal. Elsewhere, he suggested the addition of quantitative information pertaining to other aspects of the experiment.

FF8. Dr. Taleyarkhan consulted others about the manuscript, who responded to him, rather than to Dr. Xu.[9]

FF9. Dr. Taleyarkhan was heavily involved in the effort to get the manuscript published. He communicated with the Editor of Science,[10] influenced the writing,[11] and wrote the transmittal letter to PRL.[12] The changes made in response to the referee comments and the reply to the referee comments were drafted by Dr. Taleyarkhan, sent to Dr. Xu, and transmitted by Dr. Xu to the journal.[13] Dr. Taleyarkhan drove that process with PRL,[14] caused the work to be re-formatted for the special issue of NED on which he was serving as one of the editors,[15] and drafted the transmittal letter to NED editor Dr. Lohnert.[16]

FF10. On January 24, 2005 Dr. Taleyarkhan sent an email to Prof. Günter Lohnert, editor of the journal Nuclear Engineering and Design (NED) exploring the possibility of publishing the confirmatory experiment in a Festschrift.[17] The email starts out: "I've been made aware of a rather important piece of work from a nuclear engineering group here in the US

in relation to confirmatory work related to bubble nuclear fusion (thermal hydraulics and nuclear emission measurements)." This phrasing clearly carries the misleading implication that Dr. Taleyarkhan had a ***much*** more distant connection to Dr. Xu's work than was the case.

FF11. On January 26, 2005, Dr. Taleyarkhan suggested an additional figure and modified the introduction, discussion of experimental setup, and references.[18]

FF12. The NED paper includes an acknowledgment section which states: "The authors gratefully acknowledge the advice, guidance, and assistance from Dr. Taleyarkhan and Dr. J. S. Cho of Purdue University and Oak Ridge National Laboratory for design and setting up of the acoustic test cell." This acknowledgment makes no mention of Dr. Taleyarkhan's detailed guidance in the wording of the paper, nor in the source of advice in the use of the neutron detectors and the crucial pulse-shape discrimination technique which had been controversial in the past. Nor is the critical role of Dr. Taleyarkhan in the writing of the manuscript acknowledged, although some minor suggestions by Dr. Lohnert as editor are specifically noted and acknowledged: "The authors would like to recognize the encouragement and useful comments provided by Professor G. Lohnert which were helpful for improving the quality of this manuscript."

FF13. In response to a request for drafts of the NED paper, Dr. Taleyarkhan told an earlier Purdue C-22 committee that "… I made only stylistic changes and did not affect the substance, findings, conclusions, collected data, or fundamental experimental process involved for purposes of the paper."[19]

FF14. On October 27, 2006, Dr. Xu wrote a notably well-composed letter to a previous Purdue Inquiry Committee regarding the NED manuscript, stating that Dr. Taleyarkhan "did not influence, alter, change, revise or modify any of the data, analysis, conclusions or research cited in the 2005 NED paper." He further writes: "For the data and observations in my 2005 NED paper I did all the experiments myself, collected all the data independently, and did so without Dr. Taleyarkhan's involvement. I also did the analysis work with no input from him."[20]

FF15. On December 6, 2006, Dr. Xu stated: "I was unable to submit any electronic records due to the loss of my emailing files, which occurred before October 2005."[21]

FF16. On July 31, 2007, however, Dr. Xu was able to provide the Inquiry Committee with an October 14, 2004 copy of a draft of the manuscript intended for Science.[22]

FF17. Dr. Taleyarkhan states: "I did not participate in the acquisition of data presented in the 2005 publication by Xu et al."[23] "Based on all I know, it is my belief that the NED data were acquired, analyzed and reported by Dr. Xu and perhaps others assisting him, and later reviewed/checked by Mr. Butt."[24]

FF18. On July 23, 2007, Dr. Taleyarkhan told the Inquiry Committee that the contention that he played a role in preparation of the manuscript is "incorrect" and continued: "I offered editorial comments as a co-editor for this particular paper after it was accepted by the senior editor, by the editor-in-chief of the NED series journal. At that point that was the extent of my involvement over there."[25]

FF19. Dr. Taleyarkhan has subsequently stated: "My records show that I received a copy of what appears to be the initial draft date-stamped October 14, 2004, and author-stamped Yiban, of the paper submitted to Science from Dr. Xu. My understanding from talking with Dr. Xu (as noted below) is that this first draft of the paper was composed from an outline of text/figures he had prepared. I do not know where the hard copy 'original' of the paper is . . . ."[26] "After receiving the questions on 7.23.07 and the request for looking into the specific drafts of 3 years ago, I realize that it appears that the original draft of the manuscript, authored by Dr. Xu as meant for transmittal to Science was offered to me at the time for my information and possible comments."[27]

Conclusion

The Committee makes the following conclusions regarding this allegation.

The Committee cannot conclude from the evidence and testimony given to us that Dr. Taleyarkhan participated in the data collection or composition of the first draft of the manuscript for the experiments reported in the NED paper. However, it is clear from the findings of fact that he was deeply involved at every step of the research (see following sections) and in the writing and submission of the paper to the journal. Dr. Taleyarkhan clearly was not truthful in telling the Inquiry Committee that he only offered editorial comments after it was accepted by the Editor of NED (FF18), and he obfuscated the extent of his advice and involvement in the experiments (FF19 and following sections of this report).

Dr. Xu was chosen to carry out the experiments before he had completed his PhD and did the research shortly after defending his thesis. He had some experience with acoustic cavitation but apparently only a minimum of prior experience with the critical techniques of neutron detection, especially with pulse-shape discrimination. Thus, he was minimally qualified, at best, to be the lead researcher on the project. The record shows he had major gaps in his understanding of aspects of the research which required Dr. Taleyarkhan's

regular consultation.

We believe that most scientists would equate Dr. Taleyarkhan's degree of involvement with that of a research mentor and thus that of a co-author. However, as a matter of adjudicating falsification our task is different than the editorial question of who should be named as an author.

The record shows that Dr. Xu was under the direction of Dr. Taleyarkhan from March 19, 2004, onward. But it is not uncommon for a professor to mentor a post-doctoral associate's publication without insisting on co-authorship. Dr. Taleyarkhan was clearly in a position to insist on authorship. The omission of his name could be viewed as an act of generosity to a junior colleague to give more weight to the colleague's contributions. Dr. Taleyarkhan was cited in the acknowledgements of the paper, but his extensive involvements in the work and writing were not identified. Technically, that omission was Dr. Xu's responsibility.

While the Committee unanimously finds that the findings of fact do not definitively support a conclusion that Dr. Taleyarkhan had a falsifying intent in leaving his name off the NED and NURETH-11 papers, the Committee wishes to emphasize strongly that the findings of this section bear heavily on the question of independent confirmation of Dr. Taleyarkhan's sonofusion experiments reported in the Science article of 2002 (section B.2 of this report). The evidence presented to us related to this section is clearly a part of the whole picture of an effort to falsify the scientific record by assertion of independent confirmation (section B.2).

2. **Allegation:** Dr. Taleyarkhan with falsifying intent caused Mr. Adam Butt's name to be added to the author bylines of the papers even though Mr. Butt was not a significant contributor to the experiments, the data analyses, or the writing of the manuscripts.

We incorporate prior findings of fact and make the following additional findings of fact regarding this allegation.

FF1. One of the referees of the version of the manuscript submitted to PRL stated: "It is also unusual that the experiment reported was apparently done by one person so that needed cross checks and witnessing of results seem lacking."[28] The paper was later rejected.

FF2. Dr. Taleyarkhan subsequently contacted Mr. Butt on January 26, 2005 and asked Mr. Butt to check some of the numbers (the correspondence between numbers in a data sheet and the paper) and to proofread the manuscript.[29] Within 24 hours his name was added as an author.[30] The manuscript was submitted to NED on January 27, 2005 and accepted on January 30, 2005.

FF3. Dr. Taleyarkhan and Dr. Xu state that the suggestion to add Mr. Butt came from Dr. Xu.[31] According to Dr. Taleyarkhan, "Xu first approached Dr. Taleyarkhan for permission to involve Mr. Butt."[32] Therefore, Dr. Taleyarkhan controlled the decision whether to add Mr. Butt as an author. According to Dr. Xu, Dr. Taleyarkhan told Dr. Xu that adding Mr. Butt as an author "was a good idea."[33]

FF4. Mr. Butt was not cited as a collaborator on the manuscript submitted to and rejected by PRL or previous manuscripts prepared for Science, Physical Review-E, or Physical Review Letters.

FF5. On the morning of January 26, 2005, Dr. Taleyarkhan asked Mr. Butt, his master's student, to become an author on Xu's NED paper. From the outset of Mr. Butt's involvement with the NED paper, Mr. Butt's contact on the issue was Dr. Taleyarkhan.[34]

FF6. Dr. Taleyarkhan managed the submittal of the manuscript to which Mr. Butt was added.[35]

FF7. On January 26, 2005 Dr. Taleyarkhan asked Mr. Butt cc: to Dr. Xu, to review Dr. Xu's tritium-neutron work as soon as possible because Mr. Butt would be a co-author on the NED paper.[36]

FF8. Later on January 26, 2005 Dr. Taleyarkhan told Dr. Xu and Mr. Butt that the paper (which newly showed Mr. Butt as an author) looked good and

recommended adding a figure, and asked Mr. Butt to keep the process confidential until published.[37]

FF9. In a third email on January 26, 2005 Dr. Taleyarkhan wrote Dr. Xu and Mr. Butt:

> Adam: You need to send me a separate email stating that you have examined the data with Dr. Xu and find the presentation of data in the manuscript for NED to be accurate (as best you can tell).
>
> Yiban: upon discussion with Adam, after you are done modifying the manuscript with the figures etc. send me a separate email note stating you feel the manuscript is ready for journal submission to NED (to enable me to confirm with the editor-in-chief).[38]

FF10. None of Mr. Butt's changes to the NED manuscript are substantive. Most are editorial. Several changes are in the area of neutron detection.[39]

FF11. Mr. Butt testified that he only checked the transfer of numbers from a spreadsheet to the manuscript and suggested a few minor editorial changes to the NED manuscript on the day before it was submitted.[40]

FF12. Mr. Butt testified that he did not know his name was on the NURETH-11 presentation until the manuscript was completed.[41]

FF13. Mr. Butt testified that he did not contribute any of the data in the NED and NURETH papers.[42] Neither Dr. Xu nor Dr. Taleyarkhan contend that Mr. Butt participated in the acquisition of any of the data published in the NED and NURETH papers.

FF14. Mr. Butt's progress report of July, 2004, corroborates that he did not participate in the experiments reported in the NED and NURETH-11 papers. Mr. Butt was, however, doing thesis work in 2004-05 on fusion.[43]

Conclusion

The Committee makes the following conclusions regarding this allegation.

The Committee concludes that Dr. Taleyarkhan made the ultimate decision to add Mr. Butt as an author, and led the implementation of that decision. The sole apparent motivation for the addition of Mr. Butt was a desire to overcome a reviewer's criticism. Responding to the fact that the initial drafts showed Dr. Xu alone as the author, a reviewer expressed concerned about solo data acquisition. In response, Dr. Taleyarkhan urged the addition of Mr. Butt. In this context, it is plain that the intent was to create the appearance of a joint author who participated in the experimentation itself. Yet that

experimentation had occurred nearly a year before Mr. Butt was added as an author. Dr. Xu and Dr. Taleyarkhan acknowledge that Mr. Butt played no role in the data acquisition reported in the NED paper. Adding Butt as a co-author created a foreseeably misleading appearance of collaborative experimentation by Dr. Xu and Mr. Butt. This is research misconduct.

B. Allegations relating to claims of independent confirmation [IqC allegations C3, C5, D3, L1]

1. **Allegation:** Dr. Taleyarkhan with falsifying intent caused the July 12, 2005, press release from Purdue University to give credit for sponsorship and direction of the work to be published in the NED and NURETH-11 papers to Dr. Tsoukalas and to leave the impression in the press release that there was a high degree of independence of Dr. Xu and Mr. Butt from Dr. Taleyarkhan's laboratory and direction.

In addition to our findings above regarding the genesis of the NED paper, we make the following findings of fact regarding this allegation.

FF1. Dr. Xu deposited his Ph.D thesis on March 1, 2004 and was appointed to a postdoctoral position on that date. Dr. Xu's personnel file at Purdue contains Dr. Xu's appointment letter as a Post Doctoral Research Associate in School of Nuclear Engineering dated March 19, 2004.[44] The appointment letter contains the following statement:

> "In this position your work will involve research on the project entitled, Maximizing Reaction Rates in Acoustically-Induced Nuclear Fusion in Deuterated Acetone, sponsored by UT-Battelle LLC/Department of Energy. Your research will be under the direction of Dr. Taleyarkhan."

Consistent with this appointment letter, Dr. Xu affirmed on January 31, 2008 that he understood himself to be "full-time under the direction of Taleyarkhan" from the beginning of Dr. Xu's post-doctoral appointment.[45] The initial appointment on UT-Battelle/DOE funds was from March 1, 2004 to January 31, 2005. On February 1, 2005 his appointment was extended and his salary was paid from School of Nuclear Engineering departmental funds.

FF2. When Dr. Taleyarkhan learned that NED's online publication of the Xu paper was imminent, Dr. Taleyarkhan organized a press release that came out on July 12, 2005 from the Purdue University News Service.[46]

FF3. The July 12, 2005 release includes the following statements:

a. "Researchers at Purdue University have new evidence supporting earlier findings by other scientists who designed an inexpensive 'tabletop' device that uses sound waves to produce nuclear fusion reactions."

b. "the paper was written by Dr. Xu, a post-doctoral research associate in

the School of Nuclear Engineering, and Mr. Butt, a graduate research assistant in both the School of Nuclear Engineering and the School of Aeronautics."

c. "[T]he findings represent the first confirmation of findings reported earlier by Rusi Taleyarkhan."[47]

d. Dr. Xu and Mr. Butt "worked under the sponsorship and direction of Dr. Lefteri Tsoukalas, head of the School of Nuclear Engineering."

e. "Xu and Butt now work in Taleyarkhan's lab, but all the research on which the new paper is based was conducted before they joined the lab. . . ."

FF4. The experimentation reported in the NED paper occurred at Purdue in January-May 2004. In early 2004, Dr. Taleyarkhan's lab was not yet operational. According to Dr. Xu, he conducted his experiments which led to the NED and NURETH-11 papers in space controlled by Dr. Tsoukalas.[48] Dr. Xu has written that he had "overall direction from Profs. Lefteri Tsoukalas and Jevremovic during the time my NED experiments were being conducted."[49] However, Dr. Xu has also written, "Neither Drs. Tsoukalas nor Jevremovic possessed technical expertise and as a consequence did not participate in actual experimentation."[50] In fact there is no evidence that Dr. Tsoukalas had any role in the supervision of the NED experiment work. It is clear that Dr. Xu regarded Dr. Taleyarkhan as his supervisor and mentor, especially in light of the fact that Dr. Xu's postdoctoral appointment letter specifically stated "Your research will be under the direction of Dr. Taleyarkhan."

FF5. Dr. Taleyarkhan's request for a news release was misleading, by suggesting that the "news" was very recent: "A seminal development has come to our attention that is in need of a press release."[51] Dr. Taleyarkhan was driving the process and conveying a strong sense of urgency for the release to go out quickly,[52] contrary to the standard University News Service practice of taking enough time to do some background checks.[53]

FF6. The press release fails to disclose Dr. Taleyarkhan's extensive involvement with several aspects of the NED paper. Dr. Taleyarkhan did not disclose his involvement to the University News Service.

FF7. Dr. Taleyarkhan was the primary contact between the University News Service and the scientists Dr. Xu and Mr. Butt.[54] The University News Service received corrections and modifications from Dr. Taleyarkhan instead of Dr. Xu, supposedly because of Dr. Xu's language difficulties.[55]

FF8. Dr. Xu appeared for an interview with the reporter who wrote the press release. Mr. Butt was also invited to do so, but did not. Drafts of the press release circulated to Dr. Xu, Mr. Butt, and Dr. Tsoukalas, thus keeping them informed of the details of the press release and giving them ample opportunity to object to any inaccuracies.[56] However, given their status as Dr. Taleyarkhan's subordinates, Dr. Xu and Mr. Butt were hardly in a position to influence the press release significantly.

FF9. Dr. Xu and Mr. Butt posed for a picture in conjunction with the press release. Dr. Taleyarkhan's frequent collaborator Dr. Robert Nigmatulin testified that he assumed that the picture confirmed that Mr. Butt had participated in the experimental measurements reported in the NED and NURETH-11 publications.[57]

FF10. The word "independent", which appeared in the next-to-final draft, does not appear in the actual press release. The release discloses that the authors of the confirming experiments are currently junior personnel (a post doc and a graduate student) in Dr. Taleyarkhan's lab at Purdue. The drafting and email history shows that these tempering changes are attributable to cautionary editing by the Purdue News Service, not Dr. Taleyarkhan.[58]

FF11. Dr. Taleyarkhan proposed that the press release refer to "sponsorship and oversight" of Dr. Tsoukalas for Dr. Xu and Mr. Butt.[59] The implication to most readers would be that Dr. Tsoukalas had some scientific oversight responsibilities. Yet today neither Dr. Xu, nor Dr. Taleyarkhan, nor Dr. Tsoukalas assert that Dr. Tsoukalas exercised any scientific oversight of the experiment reported in NED and NURETH. There is no acknowledgement to Dr. Tsoukalas in the published NED paper.

FF12. Dr. Xu and Mr. Butt began working in Dr. Taleyarkhan's lab in May 2004.[60]

Conclusion

Experiments confirming the earlier work of Dr. Taleyarkhan would carry much more weight with other scientists if the experiments were conducted by researchers independent of his supervision. It is clear from the email trail leading up to the press release about the NED paper that Dr. Taleyarkhan wanted to emphasize the independence from him of the authors of the NED paper's "confirming" experiments. The statements in the press release focus on the independence of the authors from Dr. Taleyarkhan at the time the work for the experiments was done while acknowledging their current connection to Dr. Taleyarkhan. But a press release publicizing the work of authors who are junior researchers (Dr. Xu, a postdoctoral associate, and Mr. Butt, a graduate student candidate for the master's degree) would be incomplete without saying who supervised

them during the time the work for the experiments was done. Only Dr. Tsoukalas is mentioned in this capacity in the press release. It is true that since Dr. Taleyarkhan's lab had not been set up yet, Dr. Xu had used Dr. Tsoukalas' lab for the experiments and that Dr. Tsoukalas "supervised" everyone as department head. But the press release does not acknowledge that Dr. Taleyarkhan was responsible for directing Dr. Xu's research during the time the work for the experiments was done, as noted in his postdoctoral appointment letter, and that he functioned in that role.

No mention is made of Dr. Taleyarkhan's extensive editorial assistance for Dr. Xu with the NED paper, and the fact that Dr. Xu was actually Dr. Taleyarkhan's post-doc at the time the data were taken was obfuscated. Furthermore, as discussed in the Committee's conclusion on allegation A.2, Mr. Butt did not participate in the experiments with Dr. Xu. The only documented contribution of Mr. Butt to the NED paper occurred much later, just before it was submitted, and while Mr. Butt was an MS graduate student under the direction of Dr. Taleyarkhan.

The press release leaves one with the impression that Dr. Tsoukalas was the intellectual supervisor of the work described in the NED paper. This impression in the press release differs dramatically from the paper itself, in which Dr. Tsoukalas is never mentioned and receives no acknowledgement, while Dr. Taleyarkhan is explicitly acknowledged in the paper.

It is clear that Dr. Taleyarkhan was the mover behind the press release, but email evidence of the inclusion of Dr. Xu, Mr. Butt, and Dr. Tsoukalas in the details of the preparation of the press release show that they were kept fully informed. It should be noted that Dr. Xu and Mr. Butt were admitted to be under the supervision of Dr. Taleyarkhan at the time of the press release. The explicit confirmation and support of the final version of the written press material by Dr. Tsoukalas, as department head for Dr. Taleyarkhan, Dr. Xu, and Mr. Butt, was essential to its release.

The press release approved by Dr. Taleyarkhan gave credit to Dr. Tsoukalas (with his explicit cooperation) for "sponsorship and direction" of the work of Mr. Butt and Dr. Xu, giving the impression that these authors had a high degree of intellectual independence from Dr. Taleyarkhan at the time of the experiments reported in the NED publication. But in fact Dr. Taleyarkhan was the intellectual supervisor for Dr. Xu at the time of the experiments while Mr. Butt was not involved in the experiments.

The fact that Dr. Tsoukalas may have been complicit in this misleading statement, and approved the text[61] and in the end congratulated the press office on the release, is irrelevant to the question of Dr. Taleyarkhan's responsibility in the matter. A senior professor has considerable academic freedom, and with this freedom he must also take full responsibility for a true and fair representation of research to the outside world.

Falsifying a press release may not necessarily falsify the research record, which is the NED paper on which the press release is based. It appears that due to the selective

information provided in the press release, the information in a very technical sense is true but that the overall impression is exceedingly misleading.

The Committee, with considerable misgivings, finds that the press release, misleading as it was, did not constitute research misconduct. Much of the Committee's discussion was based on the perception that the press release was intended to influence the scientific community, as opposed to the general public, which would put it in the domain of scientific falsification. There was general agreement that the evidence was close to the line separating research misconduct from less serious violations. The evidence for this allegation bears heavily on the issue of independence (next section), since it is a clear corroboration of Dr. Taleyarkhan's intent to claim confirmation of the work reported in Science in 2002 by researchers other than Dr. Taleyarkhan. At the very least, Dr. Taleyarkhan's lack of candor in crafting the misleading press release and in his testimony to this issue reflect badly on his credibility as a scientist.

2. **Allegation:** Dr. Taleyarkhan with falsifying intent stated in the opening paragraph of his paper in Physical Review Letters **96**:034301 (2006) that "these observations [referring to Science **295**:1868 (2002)] have now been independently confirmed."

We incorporate prior findings of fact and make the following additional findings of fact regarding this allegation.

FF1. Dr. Taleyarkhan's Purdue appointment was effective on August 18, 2003.[62]

FF2. Dr. Xu has consistently asserted that he did the NED experiment alone and independently.[63] Dr. Xu asserts that he took all the data alone and did the data analyses without input from Dr. Taleyarkhan.[64]

FF3. Dr. Xu asserts that he was qualified to perform an independent confirmation of the bubble fusion experiments, having experience with bubble dynamics in his PhD thesis research and prior experience with radiation detectors.[65] He received some instruction on setting up the equipment from Joshua Walter and Anton Bougaev in Dr. Tsoukalas' group.[66] In his testimony to the Committee, he did not have good answers to questions related to detectors.[67]

FF4. Dr. Xu used Dr. Taleyarkhan's equipment for the most part, though some of the parameters in the measurements were different. Dr. Taleyarkhan was closely involved with Dr. Xu's experiment – providing the equipment, the training in the use of the equipment, and considerable continuing advice in the course of the measurements.[68] According to Dr. Revankar, only when Dr. Taleyarkhan was at Purdue and advising the researchers on most aspects of the experiments were positive results obtained.[69]

FF5. Dr. Xu described Dr. Taleyarkhan's tutoring to a C-22 committee[70] and testified to the Investigation Committee that they conferred several times a week and that Dr. Taleyarkhan checked the equipment set-ups.[71]

FF6. Dr. Xu had some experience with cavitation equipment because of his involvement with the Tsoukalas group which was (unsuccessfully) attempting to reproduce Dr. Taleyarkhan's results. Dr. Xu's thesis of February 2004 was entitled "Direct Contact Condensation with and without Non-condensable Gas in a Water Pool." Dr. Xu had very little, if any, specialized experience connected with the techniques of fast neutron detection (which was a crucial issue in the controversy), or with the detection of tritium.[72]

FF7. On October 12, 2004, Dr. Taleyarkhan wrote in an email to his collaborator, Richard Lahey: "Dick: I'd like to discuss where a certain entity (that I've helped reproduce our bubble fusion expts.) will publish/present confirmatory results for maximum impact."[73]

FF8. According to Dr. Taleyarkhan, in December 2007 he made an internet post as a "clarification for the record" regarding statements that he first made at Wayne State University in September 2005 about the work reported in the NED paper. In that 2007 post, Dr. Taleyarkhan stated that "Xu et al . . . conducted their own experiments" (thus indicating that Dr. Xu's co-authors were involved in the data acquisition), and the post asserted that the NED work was "independent experimentation." The post notes the NED paper's acknowledgement of Dr. Taleyarkhan's "advice, guidance, and assistance" along with his contribution of the test cell and its set up for the experiments, but his continuous involvement in guiding the research and in the publication process are not disclosed in the "clarification".[74]

Conclusion

The original experiments of Dr. Taleyarkhan and collaborators at Oak Ridge reporting nuclear fusion associated with acoustic cavitation were published in 2002 and 2004.[75] These results were controversial, and other investigators had difficulty reproducing them.[76] Independent confirmation of the results was clearly highly desirable.

It is not unusual for a senior person in science to mentor a junior colleague, advise and assist him in a number of ways, yet withhold the advisor's name from the resultant publication. But when it comes to a critical measurement whose objective is the ***confirmation*** of a result that the senior person has published, and that others had difficulty reproducing, then such withholding takes on a very different aspect. To quote a dictionary definition: "Reproducibility is one of the main principles of the scientific method, and refers to the ability of a test or experiment to be accurately reproduced, or replicated, by someone else working independently. Reproducibility is different from repeatability, which measures the success rate in successive experiments, possibly conducted by the same experimenters."[77]

The Committee finds much fault with Dr. Taleyarkhan's intent in advocating the independence of the Xu experiment. As documented in the findings of sections A.1 and B.1, regarding the period from October 2004 through to the present, Dr. Taleyarkhan has repeatedly mischaracterized the facts regarding his own involvement in Dr. Xu's manuscript. He has at times affirmatively misled Purdue University on this subject and appears to have influenced Dr. Xu's interactions with University inquiries. Clearly, a concerted effort went into creating a false picture of the degree of independence that was involved in Dr. Xu's experiments. Given Dr. Taleyarkhan's insistent promotion of the Xu work, he should be completely transparent to the scientific world regarding his relationship to that work. The Committee condemns his failure to do so.

Regardless of whether Dr. Taleyarkhan should have appeared as a co-author on Dr. Xu's NED and NURETH publications, Dr. Taleyarkhan himself well knew the degree of his direct mentoring, editing, and promotion of Dr. Xu's work and the resulting publication. As detailed in the discussion above regarding the July 12, 2005 press release, Dr. Taleyarkhan was determined to direct the audience away from the facts of his involvement. Dr. Taleyarkhan's December 2007 "clarification of the record" post (FF8, above) belies his current assertion that he was not personally a proponent of Dr. Xu's work as "independent" and the post is additional evidence of Dr. Taleyarkhan's intent to obscure his own role.

Therefore, the Committee concludes that Dr. Taleyarkhan's PRL characterization of Dr. Xu's work as independent was intended to obscure his direct involvement with the Dr. Xu work. This is research misconduct.

C. Allegation of falsification of calibration data [IqC allegation C6]

Allegation: Dr. Taleyarkhan with falsifying intent used identical calibration data in the NED and NURETH-11 papers and in his publication in Multiphase Science and Technology **17**:191-224 (2005), implying that the data refer to the same experiment.

We make the following finding of fact regarding this allegation.

FF1. The Committee received both verbal and written testimony that all of the authors agreed to the sharing of the data.[78]

FF2. Dr. Taleyarkhan has acknowledged that he was negligent in failing to include a proper citation in the original submission.[79] Dr. Taleyarkhan has submitted an errata letter to MST to add a proper citation to the figure.[80]

Conclusion

The Committee finds the testimony of the scientists involved to be consistent, and none believe that their work was plagiarized. Copyrights were apparently violated, since no citations were provided in the later publications to the first. We disapprove of this inattention to proper citation and flouting of copyright laws. However, the charge of falsification or plagiarism is not supported by the evidence.

D. Allegations of plagiarism [IqC allegations E1, E3]

Allegation: In his publication in Multiphase Science and Technology **17**:191-224 (2005), Dr. Taleyarkhan with falsifying intent attempted to make it appear that the same results were the outcomes of several experiments by re-publishing previously published data without citing the original publications.

The Committee makes the following findings of fact regarding this allegation.

FF1. The Xu data in Dr. Taleyarkhan's MST publication appeared in Dr. Xu's above-discussed publications, and figures from Dr. Xu's earlier published works were reproduced verbatim without citation.

FF2. Dr. Xu gave his permission to use his data in Dr. Taleyarkhan's MST publication.[81]

FF3. The MST and NURETH-11 reports are conference proceedings intended to be review articles covering a comprehensive subject, and thus are expected to include previously published data.

FF4. Dr. Taleyarkhan has submitted an errata letter to MST acknowledging the omission of attribution.[82]

Conclusion

The Committee finds the testimony of the scientists involved to be consistent, and none believe that their work was plagiarized. Again, copyrights were apparently violated, and we disapprove of the lack of appropriate citations. Dr. Taleyarkhan's after-the-fact admissions of errata do not appear in the original work, so readers of the original paper may be misled regarding the originality of the data. However, we find no compelling evidence of plagiarism in the sense of appropriating the data of another scientist without approval of that individual. We also find no obvious evidence for an intent to deceive, but rather a very unprofessional inattention to important details.

E. Allegations of non-disclosure of federal funding [IqC allegation F2]

Allegation: Dr. Taleyarkhan used federal funds for the work published in Physical Review Letters **96**:034301 (2006) and with falsifying intent failed in the publication to acknowledge federal support.

The Committee makes the following findings of fact on this allegation.

FF1. Dr. Taleyarkhan testified that the work that led to the PRL **96** paper occurred over a period of years.[83]

FF2. Dr. Taleyarkhan reported that much of the data acquisition and analysis reported in the PRL paper was supported by grants from the Department of Energy and Purdue Research Foundation Trask fund, and was completed before the DARPA funding commenced in the spring of 2005. He has provided dated scientific equipment records as evidence that experiments like those reported in the PRL **96** paper were conducted during 2004.[84] However Dr. Taleyarkhan has not provided evidence documenting when the specific data reported in the PRL **96** paper were collected.

FF3. The first communication to the PRL **96** authors summarizing the work described in the final published PRL **96** manuscript has been provided to the Committee and is dated June 24, 2005.[85] A manuscript describing the work reported in the PRL **96** paper was submitted to Science on August 26, 2005. This manuscript was rejected by Science. Manuscripts describing these data were subsequently submitted to Nature, which also rejected the manuscripts. A manuscript was submitted to PRL on September 16, 2005 by co-author Robert Block and subsequently accepted on November 29, 2005.[86]

FF4. Purdue payroll records document that Dr. Taleyarkhan's salary for the period May 16, 2005 to August 19, 2005 was charged 100% to the UCLA subcontract of DARPA funds. Dr. Taleyarkhan certified on his Personnel Activity Report for Summer 2005/2006 dated October 13, 2005 that 100% of his effort for the summer period benefited to the UCLA subcontract of DARPA funds.[87] Therefore, it is clear that 100% of Dr. Taleyarkhan's salary during the period that the PRL **96** paper was being written was charged to DARPA funding.

FF5. Dr. Taleyarkhan has provided email evidence documenting that the program administrator from the Department of Energy, Dr. Carl Pocratsky, informed Dr. Taleyarkhan on January 3, 2007 that it was not necessary to modify the PRL **96** manuscript to acknowledge DOE support.

Conclusion

The question before us is whether the PRL publication falsified the record regarding a federal funding source. Dr. Taleyarkhan should have acknowledged in the PRL**96** publication that DARPA funding supported at least his preparation of the PRL manuscript. However, we lack evidence that he possessed a falsifying intent for that omission, so we do not find research misconduct.

F. Allegation of deletion of published data in response to a critique [IqC allegation G2]

Allegation: In his published response to a forensic analysis by Dr. Brian Naranjo in Physical Review Letters (PRL) **97**:149404, Dr. Taleyarkhan claims to show the same fusion data but, allegedly, actually deleted some of his originally published research results.

The Committee makes the following findings of fact on this allegation.

FF1. The datum in question was omitted without explanation, and the relative normalization of the calculation presented there to the data was not discussed in PRL**97**:149404.

FF2. Dr. Taleyarkhan normalized the calculation obtained from Dr. Naranjo to the data in the region where the calculation existed. The lower channels, those omitted in his response to the critique, had not been calculated by Dr. Naranjo.[88]

Conclusion

Dr. Taleyarkhan's explanation is scientifically defensible provided that the datum in the lowest channel[89] is anomalous and not to be trusted. The Committee notes that the figure[90] that was actually published and reproduced by Dr. Naranjo in his critique[91] does not in fact show the anomaly in question to be outside of the statistics of the data. The higher-statistics data shown by Dr. Taleyarkhan in his response to the critique actually appeared only in the supplement to the paper.[92] As a result, we conclude that the omission of the datum in the lowest channel of Fig. 1 of PRL**97**:149404 was scientifically defensible and therefore not an instance of research misconduct.

G. Allegation of falsified fusion demonstration [IqC allegation K1]

Allegation: Dr. Taleyarkhan falsified a September 19, 2003 fusion demonstration carried out at Purdue by him and Dr. Cho of Oak Ridge National Laboratory.

FF1. The results of the demonstration were a "work in progress" and possibly unsuited for publication. In fact, they have never been published.

FF2. There are discrepancies in the testimony regarding this demonstration. The source of the allegation (Dr. Joshua Walter) claims to have personally observed the September 19, 2003 demonstration, and gave a detailed description of it in his testimony.[93] He is supported in this by testimony given by Dr. Tsoukalas.[94] However, Dr. Revankar stated that he did not believe Walter was present,[95] and Dr. Taleyarkhan testified that Walter left the laboratory by mid-morning of September 19, 2003 and did not return that day.[96] Dr. Taleyarkhan is supported in this by the log book for the G60 laboratory.

FF3. Dr. Walter also provided a figure allegedly taken on September 19, 2003 that appears to show no "bubble-fusion" signal. Dr. Taleyarkhan testified that this figure could not have been taken by Dr. Walter on that date.[97]

Conclusion

The Committee finds no convincing evidence of a deliberate attempt to mislead either the scientific community or the viewers of this demonstration. We find that the falsification of data charges have not been proven.

However, it is difficult to understand how the so-called "neutron peak" in the pulse-shape discrimination ("PSD") spectrum from the September 19, 2003 demonstration could have been generated, as was already pointed out in the August 27, 2007 Purdue Inquiry Committee report. Dr. Block, the expert in neutron detection using a PSD who is working with Dr. Taleyarkhan, helped to prepare the "Response to Allegations" (Appendix J of the August 27, 2007 report). He stated both there and in his affidavit to this Committee[98] that the neutron-gamma delay difference in the PSD spectrum was "consistent with expectations," and that the concerns of the Inquiry Committee have no merit. However, when asked about the observed time difference of ~200 ns (up to 15 times the separation of 15 to 25 ns observed by other groups), he stated that he had not actually analyzed the PSD spectra either from this demonstration or from the calibration runs taken with similar detectors at the RPI linac laboratory and therefore could not comment on this point.[99] The Committee notes that there are other technical concerns with the archived data from the September 19, 2003 demonstration, and the explanations for them proposed in the "Response to Allegations," but it is not necessary to discuss these in detail. There appears to be sufficient evidence to conclude that the response to neutrons of the detectors and electronics used in this demonstration was not understood

by Dr. Taleyarkhan and the other members of his research group. To quote Dr. Block: "I didn't care about that. I was interested in just using it for separating neutrons from gammas."[100] This may be poor scholarship, but it is not sufficient to sustain a charge of research misconduct.

H. Comment on ^{252}Cf issues

Although the Inquiry Committee received allegations of intentional data fabrication through the use of ^{252}Cf, those allegations were not forwarded to our committee. Nonetheless, given the published debate instigated by Dr. Naranjo on this issue, we wish to preserve some observations here.

Dr. Taleyarkhan's prior work at Oak Ridge is beyond the C-22 jurisdiction.

There is no report that a ^{252}Cf source was present during the PRL**96** experiment. Dr. Xu's NED paper does expressly acknowledge that "… the 1 Ci Pu-Be isotope neutron source could not be relocated. Instead, a 0.5 mCi Cf-252 isotope neutron source was available for use" to seed bubble growth for the neutron-emission measurement part of the experiment. Available information indicates that Dr. Xu is the only person who carried out that experiment. As a result, any improper use of a ^{252}Cf source would be his responsibility.

Of course Dr. Xu does not attribute the sonofusion signal reported in the NED paper to any improper use of ^{252}Cf. Dr. Naranjo, who has published a model simulating ^{252}Cf as a generator of reported sonofusion signals, was asked by the Inquiry Committee if his simulation would preclude the truthfulness of an eyewitness affirmation regarding the lack of data fabrication via ^{252}Cf. Dr. Naranjo would not claim that his simulation had such power. The potential proof value of Dr. Naranjo's analysis would be as corroboration of the credibility of an eyewitness to data fabrication via ^{252}Cf. The record is devoid of an eyewitness to such data fabrication.

As part of our effort to familiarize ourselves with the research papers before us, we chose to delve further into the neutron spectrum in measurements reported by Dr. Taleyarkhan and/or Dr. Xu. In particular, there is still the issue of the "ice pack" between the cavitation chamber and the liquid-scintillator (LS) detector. This is the explanation cited for the "anomalous" shape of the neutron spectrum in all these measurements. This very important detail is never indicated on any of the schematic diagrams of these experiments by Dr. Taleyarkhan and/or Dr. Xu, which always appear to show an uninterrupted path between the chamber and the LS detector. Furthermore, the effect of this ice pack on the expected neutron detection energy and efficiency was not discussed in any of the papers. In his testimony to us, Dr. Xu seemed to indicate that the LS detector had an unobstructed view of the cavitation chamber despite the fact that his neutron spectrum looks very much like that obtained in the other experiments where an ice pack or other intervening material was supposedly present. Perhaps this was due to the fact that he either did not understand the question or we did not understand his answer. Also, Dr. Taleyarkhan claimed in his testimony that the ice packs were indicated on the figures in his papers. This is not the case. Ice packs were shown, but there was no clear indication of any ice or other obstructions between the LS detector and the chamber. As Dr. Naranjo has shown in his Monte-Carlo simulations, the presence of ice packs surrounding the chamber will not result in a spectrum like that displayed in Dr. Taleyarkhan's papers

unless the ice is directly between the chamber and the detector.

Dr. Taleyarkhan was most probably unaware of the effect of the ice packs on his experiment until this was brought to his attention by Dr. Naranjo's simulations. Dr. Block's testimony to us made clear that the PRL**96** authors were not concerned with understanding the response of the neutron detectors and relied entirely on the differences between the spectra taken with deuterated and non-deuterated liquids. This is evidence of poor scholarship, but not fraud. Unfortunately, it also left them open to the charges of fraud that were ultimately made.

Concluding Observations

Ideally, the publication of any scientific investigation should contain enough detail so that any scientist anywhere in the world who possesses the knowledge and equipment to do the experiments can reproduce the work. When a revolutionary observation is made, and bubble fusion certainly meets that criterion, many scientists will be eager to repeat the experiments and start the process of moving the field forward. That certainly was the case with the publication of Dr. Taleyarkhan's 2002 paper in Science. A number of scientists, including members of the Purdue School of Nuclear Engineering, began correspondence with Dr. Taleyarkhan to learn the details of the experiment with the intention of replicating it and moving forward with the next steps in the process.

Most attempts at replication by others have failed. All reports in rigorously reviewed journals of successful replication of which the Investigation Committee was made aware involve Dr. Taleyarkhan's equipment, his close involvement with the work, and/or subsequent co-authorship of the papers.

The papers at issue in this investigation, those published by Dr. Xu and Mr. Butt in Nuclear Engineering and Design (NED) and by Dr. Xu, Mr. Butt, and Dr. Revankar in NURETH-11, are in volumes which were very lightly reviewed, at best. The former is in a Festschrift on the occasion of Richard Lahey's 65th birthday, and the latter is a conference proceeding. Had those been simply published in the respective volumes, they may well have not received much notice, and even interested scientists who may have noticed the papers and the University of origin may have attributed the work to Dr. Taleyarkhan's group and not attached "independence" to the experiments. However, Dr. Taleyarkhan initiated and drove a very rushed press release just prior to the paper in NED becoming public which conveyed by carefully-chosen wording the impression that direction of Dr. Xu and Mr. Butt was provided by Dr. Tsoukalas, the Head of Nuclear Engineering at Purdue. The words "sponsorship and direction" appear in the final press release, a phrase that scientists would immediately assume means "scientific direction", not merely fiscal support. A more direct assertion of independence of the work by Dr. Xu and Mr. Butt then appeared in a 2006 paper by Dr. Taleyarkhan and co-workers (including Dr. Xu) in Physical Review Letters **96**. The Investigation Committee has found that the weight of the evidence indicates that Dr. Taleyarkhan's involvement in the work that led to the NED and NURETH-11 papers was so extensive that claims of "independent confirmation" simply cannot be supported.

A further issue relates to the lack of qualifications of both Dr. Xu and Mr. Butt to pursue this work independently. Dr. Xu had graduate training in bubble dynamics, but lacked training in many aspects of the research. Thus, his regular consultation with Dr. Taleyarkhan was both appropriate and necessary. Mr. Butt had very little relevant experience in the field. These issues further support the lack of independence in the conduct of the research and the inappropriate choices of authors for the papers.

Consequences for science:

The observations that Dr. Taleyarkhan and co-workers made and reported in Science in 2002 are very interesting. Dr. Taleyarkhan is clearly excited and passionately involved in the research and his defense of the findings. This is entirely appropriate for any scientist; science is a painstaking enterprise in most cases, especially where entirely new ground is being broken. But the record clearly shows that his passion extended beyond the scientific passion every scientist must possess and led him to describe the research by Dr. Xu as "independent" and to support inappropriate authorship of scientific papers. It further led him to become engaged in personal acrimony with critics that prevented definitive replication of the bubble fusion experiments and recriminations in the non-scientific literature, never a helpful development for science.

Sonofusion, if it occurs, involves an unusual amount of scientific "art." Most, maybe all, sonofusion experiments that have been claimed to be successful have been run on Dr. Taleyarkhan's apparatus or with his involvement. That being so, it is incumbent on all parties to engage in careful replication experiments with skeptics being able to observe and participate in every aspect of set-up, experimentation, and data analyses. When the personal animosities escalated to the point where communication ceased in both directions, such collaborations became impossible and led to recrimination and further conflict. This situation has no place in science. Scientists have to be able to bury any perceived insults and their personal feelings about their critics and work dispassionately together to resolve scientific disagreements. This clearly did not happen in this case. Collegiality failed as the conflict, which should have been contained within the department and University, was played out in the media. Consequently, the observation, interesting as it is, is not being pursued effectively, and science is the poorer for it.

Press releases:

Any scientific discovery of consequence needs to be confirmed and integrated into the framework of the field of research. This is normally done by replication by other scientists. Where disagreements arise, collaborations need to occur to settle the ambiguities and differences of opinions. Only when firm evidence is obtained should releases to the popular press occur, and the more revolutionary the findings, the more the level of caution that should be exercised. This level of caution clearly was not employed in the July 2005 release. Dr. Taleyarkhan, Dr. Tsoukalas, and the University News Service bear responsibility for this. The process was rushed and did not employ the external checks which the News Service customarily employs. Why did it rely on Professor Taleyarkhan's assertions about Dr. Xu's work? Why did it yield to pressure to release quickly, reducing the time for due diligence to almost nothing? Why was there not more skepticism about Dr. Tsoukalas' role? The News Service does deserve credit for removing the work "independent" from the final version of the press release.

Overall assessment:

The findings of misconduct related to authorship and assertions of independent confirmation of research results, while serious, are less serious than reporting fraudulent research findings.

Again, the publication of the NED and NURETH-11 papers without Dr. Taleyarkhan's name in the author list and with the inclusion of a graduate student who did none of the work would probably not have made much of an impact were it not for the press release and follow-up publication by Dr. Taleyarkhan in PRL claiming independent verification to both the general and scientific publics. These events certainly did nothing to quell the disputes, but rather inflamed them. This has impeded the progress of science and corrupted the scientific and public records.

The Committee views the effects of this matter on the students and post-doctoral fellows as especially deplorable. Mentors of young scientists need to exhibit the highest standards of ethical behavior and collegiality. Dr. Taleyarkhan failed to do so.

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[1] 1/31/08 Xu letter p. 1.

[2] 12/6/06 letter from Xu to Dunn.

[3] 1/31/08 Xu letter p. 4; 4/7/08 Taleyarkhan submission, p. 36; 12/18/07 Taleyarkhan submission p. 11.

[4] 4/7/08 Taleyarkhan submission, p. 36.

[5] February 2008 Hearing Transcript pp. 112, 136-137.

[6] February 2008 Hearing Transcript p. 57; 12/18/07 Taleyarkhan submission, p. 11.

[7] 10/15/04 email from Taleyarkhan to Xu.

[8] Email from Taleyarkhan to Xu on Thursday, 12/16/04, 6:31 p.m. with subject line: "Re: Revised paper to PRE (12/16/04)." [Note: PRE is a typo in the original message.] The attachment is entitled: ConfExpt2004 (Dr. Xu-final)_rev1-3.doc.

[9] 10/24/04 email from West to Taleyarkhan re: Confirmatory paper to PRL.

[10] 10/14/04 email from Taleyarkhan to laheyr@rpi.ede re: Upcoming Bubble Nuclear Fusion Article in Phys.Rev.E Journal.

[11] 10/21/04 email from Xu to Taleyarkhan re: manuscript to PRL.

[12] 10/28/04 email from Taleyarkhan to Xu re: Manuscript es2004oct21_103 has been submitted to Physical Review Letters.

[13] 11/30/04 email from Xu to Taleyarkhan re: Your_manuscript LX9468 Xu; 12/14/04 email from Taleyarkhan to Xu re: Your_manuscript LX9468 Xu (fwd) – Responses to send; 12/17/04 email from

Taleyarkhan to Xu re: Modified response letter, letter attached; 12/17/04 email from Xu to Taleyarkhan re: response to referee comments for manuscript number LX9468 "Confirmatory Experiments for Nuclear Emissions during Acoustic Cavitation" (fwd).

[14] 10/28/04 email from Xu to Taleyarkhan re: Status of Manuscript es2004oct21_103 has been submitted to Physical Review Letters.

[15] 1/25/05 email from Taleyarkhan to Xu re: NED paper report attached.

[16] 1/27/05 email from Taleyarkhan to Xu and Butt re: Communication with NED.

[17] 1/24/05 email from Taleyarkhan to Prof. Gunter Lohnert re: High-Impact Paper Addition Possibility; 1/25/05 email from Prof. Lohnert to Taleyarkhan re: Paper on bubble nuclear fusion.

[18] 1/26/05 email from Taleyarkhan to Xu and Butt re: Revised NED paper.

[19] 10/31/06 letter from Taleyarkhan to Dunn.

[20] 10/27/06 letter from Xu to Dunn.

[21] 12/6/06 letter from Xu to Dunn

[22] ONR IqC 2007 070731 YXu.1 and ONR IqC 2007 070731 YXu.attach1.

[23] 6/9/07 letter from Taleyarkhan to Dunn, p. 1.

[24] 6/9/07 letter from Taleyarkhan to Dunn, p. 2.

[25] 7/23/07 Transcript of interview of Taleyarkhan p. 15.

[26] 2/2/08 Taleyarkhan affidavit, ¶ 4; ONR IqC 2007 070802 LSelander.ExhibitB.1.

[27] 2/2/08 Taleyarkhan affidavit, ¶ 14; ONR IqC 2007 070802 LSelander.ExhibitB.6.

[28] ONR IqC 2007 041130 YX to RT.2.

[29] February 2008 Hearing Transcript p. 169; 1/26/05 email from Taleyarkhan to Butt re: no subject.

[30] February 2008 Hearing Transcript p. 170; 1/26/05 email from Taleyarkhan to Xu and Butt re: revised NED paper.

[31] February 2008 Hearing Transcript pp. 73, 273; 1/31/08 Xu letter p. 2.

[32] 4/7/08 Taleyarkhan submission p. 22.

[33] 1/31/08 Xu letter p. 2; February 2008 Hearing Transcript p. 73:15-16.

[34] February 2008 Hearing Transcript pp. 169-70.

[35] 1/26/05 email from Taleyarkhan to Xu and Butt re: NED paper (revised); 1/27/05 email from Xu to Taleyarkhan and Butt re: NED paper final manuscript; 1/27/05 email from Xu to Taleyarkhan and Butt re: updated final version; 1/27/05 email from Xu to Taleyarkhan and Butt re: wrong version again, this time is right; 1/27/05 email from Taleyarkhan to Xu and Butt re: Communication with NED.

[36] 1/26/05 email from Taleyarkhan to Butt and Xu, re: no subject.

[37] 1/26/05 email from Taleyarkhan to Xu and Butt re: NED paper (revised).

[38] 1/26/05 email from Taleyarkhan to Xu and Butt re: Revised NED paper.

[39] 1/27/05 email from Butt to Xu and Taleyarkhan re: Revised NED paper.

[40] February 2008 Hearing Transcript pp. 165, 174; 9/22/06 Butt-Dunn exchange.

[41] February 2008 Hearing Transcript pp. 166-67.

[42] February 2008 Hearing Transcript p. 167.

[43] "Sonofusion Lab 2004 Summer Activities" Adam Butt, 8/6/04; M.S. Thesis, Aeronauts and Astronautics, "Acoustic Confinement Fusion: Potential Applications to Space Power and Propulsion", 12/1/05, Ivana Hrbud, Dr. Taleyarkhan, Advisors; M.S. Thesis Nuclear Engineering, "Acoustic Confinement Fusion: Characterization of Reaction Chamber", 12/1/05, Taleyarkhan, Ivana Hrbud, Advisors.

[44] 3/19/04 letter from Tsoukalas to Xu.

[45] 1/31/08 Xu letter p. 1.

[46] Venere 2007 submission pp. 2-3; Venere 2008 submission, Timeline.

[47] An earlier draft of the press release included the work "independent" before "confirmation" in this sentence. Venere 2008 submission, Item 10.

[48] 1/31/08 Xu letter p. 1; Venere 2008 submission, Items 2-3.

[49] 7/31/07 letter from Xu to Dunn p. 3 (ONR IqC 2007 070731 YXu.3).

[50] 7/31/07 letter from Xu to Dunn p. 3 (ONR IqC 2007 070731 YXu.3).

[51] Venere 2007 submission p. 2; Venere 2008 submission, Items 2-3.

[52] 7/20/07 Memo from Selander to Inquiry Committee p. 6; Venere 2007 submission p. 4; Venere 2008 submission, Timeline.

[53] February 2008 Hearing Transcript p. 26.

[54] 7/20/07 submission from Selander to Inquiry Committee pp. 6-7; February 2008 Hearing Transcript p. 6.

[55] Venere 2007 and 2008 submissions; February 2008 Hearing Transcript p. 6.

[56] Venere 2007 and 2008 submissions.

[57] February 2008 Hearing Transcript p. 537.

[58] Venere 2008 submission.

[59] Venere 2008 submission, Item 10; February 2008 Hearing Transcript pp. 27-29.

[60] February 2008 Hearing Transcript pp. 311-12, 327-30.

[61] Venere 2007 submission p. 15; Venere 2008 submission, Item 10.

[62] 6/18/03 letter from Tsoukalas to Taleyarkhan.

[63] 10/27/06 letter from Xu to Dunn; 7/31/07 letter from Xu to Dunn; February 2008 Hearing Transcript p. 58.

[64] 10/27/06 letter from Xu to Dunn.

[65] February 2008 Hearing Transcript p. 54.

[66] February 2008 Hearing Transcript p. 56.

[67] February 2008 Hearing Transcript pp. 59-63.

[68] FF2, allegation A-1.

[69] 9/22/06 Revankar-Dunn exchange.

[70] 9/22/06 Xu-Dunn exchange.

[71] February 2008 Hearing Transcript p. 64.

[72] February 2008 Hearing Transcript pp. 61-63.

[73] ONR IqC 2007 041012 RT to DL. 1.

[74] 12/18/07 Taleyarkhan submission pp. 103-104; 2/6/08 Taleyarkhan submission, Appendix 4 pp. 16-19.

[75] R.P. Taleyarkhan *et al.*, Science **295,** 1868 (2002); R.P. Taleyarkhan *et al.*, Phys. Rev. E **69**, 036109 (2004).

[76] D. Shapira and M. Saltmarsh, Phys. Rev. Lett. **89**, 104302 (2002).

[77] http://en.wikipedia.org/wiki/Reproducibility.

[78] February 2008 Hearing Transcript p. 83; February 2008 Hearing Transcript p. 420; Taleyarkhan 2/6/08 submission, exhibit 4.2.

[79] February 2008 Hearing Transcript p. 418.

[80] 2/6/08 Taleyarkhan submission, Appendix 4, pp. 13-15.

[81] See note 78.

[82] See note 80.

[83] February 2008 Hearing Transcript pp. 421-23; 2/6/08 Taleyarkhan submission, Appendix 1 pp. 1, 6.

[84] 3/4/08 Taleyarkhan submission, Ex. 2 [ONR InvC2007 080304 RT.6-9].

[85] 2/6/08 Taleyarkhan submission.

[86] 12/18/07 Taleyarkhan submission p. 38; 2/6/08 Taleyarkhan submission, Appendix 1 pp. 3-4 and Exhibit 1.4.

[87] ONR InvC 2007 080305 055PAR.2.

[88] 12/18/07 Taleyarkhan submission pp. 63-67; February 2008 Hearing Transcript pp. 287-289.

[89] Omitted from Fig. 1 of *PRL***97**:149404.

[90] Fig. 4 in *PRL***96**:034301

[91] *PRL***97**:149403.

[92] E-PRLTAO-96-019605.

[93] February 2008 Hearing Transcript pp. 391-392.

[94] February 2008 Hearing Transcript p. 185.

[95] February 2008 Hearing Transcript p. 132.

[96] February 2008 Hearing Transcript pp. 252-254, 258, 432, 435.

[97] February 2008 Hearing Transcript pp. 432-34.

[98] February 2008 Hearing Transcript p. 522.

[99] February 2008 Hearing Transcript p. 523.

[100] February 2008 Hearing Transcript p. 523.

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