Report of the Inquiry Committee on the Matter of Allegations of Research Misconduct by Professor Rusi Taleyarkhan

This report summarizes the findings of the Purdue University Inquiry Committee (IqC) appointed by Dean of Engineering, Leah Jamieson, on April 13, 2007 in response to allegations of possible research misconduct by Prof. Rusi Taleyarkhan (RT). Throughout our deliberations, we have adhered to the procedures outlined in the University's Executive Memorandum No. C-22.

This report is organized as follows:

1. Preamble

The Inquiry Committee (IqC) adopted the guiding principle that allegations pertaining to scientific work conducted by Rusi Taleyarkhan (RT) either at Purdue University or under its auspices fall under the University's jurisdiction. Those allegations that do not meet these criteria are the responsibility of the appropriate funding agency, national laboratory or sponsor organization.

Executive Memorandum C-22 defines research misconduct as fabrication, falsification, plagiarism, or "other practices that seriously deviate from those that are commonly accepted within the scientific and academic community for proposing, conducting, or reporting research. It does not include honest error or honest differences in interpretations or judgments of data."

The IqC recognizes that this fourth category of "other practices" is not universally accepted as an element of the core definition of misconduct in science primarily because of its lack of specificity.[1] Purdue University has chosen to include it as a category of research misconduct, following the regulatory definitions adopted by the Public Health Service (PHS)[2] "Responsibilities of PHS awardee and applicant institutions for dealing with and reporting possible misconduct in science: final rule"[3] and the National Science Foundation (NSF) "Misconduct in science and engineering: final rule".[4] While it may not be possible to provide a precise and all-encompassing definition of practices that would qualify as research misconduct, the IqC is confident that a vast majority of scientists, and particularly senior scientists, would be capable of recognizing behavior and practices that they could readily and confidently identify as deviating from those that are commonly accepted within the scientific and academic community.

The previous Inquiry Committee, whose findings were communicated to Dean of Engineering, Leah Jamieson, on December 15, 2006, was narrowly focused on the few allegations before it. In contrast, the current Inquiry Committee has considered over thirty allegations from multiple sources.

The Congressional Subcommittee on Investigations and Oversight has called the outcome of Purdue's initial Inquiry Committee's investigation of research misconduct surrounding the work of Dr. Taleyarkhan into question. The formation of the initial Inquiry Committee was triggered by charges emerging from the School of Nuclear Engineering at Purdue. An ad hoc committee was appointed by the Head of that School, Dr. Lefteri Tsoukalas to investigate suspicions of research misconduct with respect to sonofusion research. This internal committee was formed outside the guidelines of C-22, and failed to directly interview the accused. That investigation, coupled with well-timed articles

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[1] *Responsible Science : Ensuring the Integrity of the Research Process*, Vol I, National Academy of Sciences (1992).
[2] Department of Health and Human Services (DHHS)
[3] *Federal Register* 54 (August 8):32446-32451
[4] *Federal Register* 56 (May 14):22286-90

published in the scientific and public press, quickly ballooned into widespread coverage across the internet. Specific written allegations accompanied by supporting documentation only emerged after a lengthy review process. Even so, the written allegations that surfaced had quite a limited focus.

In retrospect, both internal and external critics calling for misconduct somehow failed to understand that an allegation must be specific enough to be actionable and that sufficient evidence must also be presented for any allegation to go forward. It can be inferred that these points are not clearly emphasized in the current version of Purdue's Executive Memorandum C-22 that governs such affairs.[5]

The current Inquiry Committee has revisited all earlier allegations in light of new evidence acquired. In addition, this IqC suspects intent on the part of Taleyarkhan to obstruct the IqC's inquiry into his actions.

Not all of the allegations under consideration are unique, and quite a few are poorly framed. Consequently, this Inquiry Committee has taken a broader view of the entire set of allegations. In addition to examining the specific allegations, the Committee has distilled from this set additional issues that warrant further investigation. These will be discussed in section 4 of this report.

2. General Observations Regarding Rusi Taleyarkhan in his Role as Scientist and Mentor

The overwhelming impression one is left with after examining the body of evidence put before the IqC is that RT is a vigorous advocate of his sonofusion results. Enthusiasm for one's work is, in itself, not a rare or unprofessional trait. The IqC recognizes that there are many critics of sonofusion and the results reported by RT, and, in a real sense, both scientists and journalists are calling his scientific credibility into question.[6] (A compilation of scientific papers and presentations related to sonofusion is tabulated in Appendix K.) Some of the actions taken by RT might be viewed from the perspective of a scientist under siege. Unfortunately, many of these actions have served only to undermine the credibility of the work and to increase the skepticism of its critics. (See Allegation M3 and Appendices F-J.)

The IqC conducted an interview of Taleyarkhan on July 23, 2007 as part of the process of discovery. We did not interview any of his collaborators or supporters, although we did communicate in writing with some of them in an effort to obtain and verify information provided to the committee. (See Appendix C for List of Contacts.)

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[5] http://www.purdue.edu/policies/pages/teach_res_outreach/c_22_print.html

[6] This complicated history is described in *New Energy Times* Special Report on Bubble/Sonofusion, Steven B. Krivit, http://www.newenergytimes.com/BubbleTrouble/NETBubbleFusionSpecialReport.pdf, which presents a largely sympathetic view of sonofusion research but also enumerates its criticisms.

Bubble fusion experiments conducted by and under the direction of RT have produced signals that have been interpreted as indications that deuterium-deuterium (D-D) fusion has been achieved in acoustic cavitation. We have **not** been charged with the task of determining the veracity of this interpretation. We will leave this exercise to the scientific community. Nonetheless, we have included a partial analysis of two of Taleyarkhan's publications, *Physical Review Letters* 2006 and *Science* 2002, in Appendices F and G, respectively.

In order for the scientific community to be in a position to make a careful and considered evaluation of the work done by Taleyarkhan, it is incumbent upon him (and his co-authors) to adhere to the standards of scholarship widely recognized in the general scientific community. It is in the arena of scholarship that the IqC has concerns regarding the quality of work reported by Taleyarkhan.

Scientists have an obligation to exercise critical self-discipline and judgment when conducting and reporting research. If these obligations are not honored, then the ensuing research may be considered flawed. Flawed research can be identified by a disregard for scholarship or by a lack of proficiency in executing technical matters.

The Nobel Prize winning physicist Richard Feynman, in his 1974 Cal Tech Commencement address, expressed the hallmarks of good scholarship as follows:

> ...if you're doing an experiment, you should report everything that you think might make it invalid – not only what you think is right about it: other causes that could possibly explain your results; and things you thought of that you've eliminated by some other experiment, and how they worked – to make sure the other fellow can tell they have been eliminated.[7]

There is a fine line between obstruction and falsification, which is a deliberate misrepresentation of the truth or facts. The basic issue regards a judgment about the fair and accurate representation of scientific work. If research is published that displays a deliberate indifference or a conscious disregard of accepted standards and norms in the reporting of scientific work, this inaccurate reporting can be grounds for research misconduct. If such behavior persists for an extended period of time, claims of either incompetence or research misconduct will naturally arise.

There is an even finer line between honest mistakes and technical incompetence. While a faculty member may make honest mistakes based on poor judgment, a named professor at a major university should pay meticulous attention to the quality of research and the accuracy of the data reported.

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[7] *Responsible Science* op. cit. p. 37.

The IqC, during its investigation, has largely refrained from judging intent since such judgment requires an accurate evaluation of motivation. However, persistent, repeated and pervasive behavior that lingers for extended periods of time around any of the fine lines mentioned above may provide valuable clues on the question of intent and motivation. Such clues should not be ignored.

This report will document the extensive body of evidence that raises concern over the scholarship practiced by Rusi Taleyarkhan. Similar concerns were expressed by the previous Inquiry Committee during their deliberations over a much narrower set of allegations. If good science is learned from good scientists, then Purdue University should have great concern about Taleyarkhan in his role as a mentor of students at any level. To some degree, his co-authors must also be held accountable for failing to meet the level of scholarship expected in a professional scientist. The same comment holds for some of the referees who reviewed papers during the peer review process.

The practice of making claims of research misconduct, often accompanied by sensational coverage in the popular press, seems to be a growing and troublesome trend in science that short-circuits the scientific process. This is a particularly ineffective means of conveying the specific nature of the potential research misconduct. While scientists must diligently police themselves and their work to ensure integrity, the proper way to conduct such monitoring action still remains the publication of well-argued and vetted manuscripts in refereed scientific journals. Nonetheless, such accusations remain an effective way to immediately negate targeted research by calling into question the integrity of an investigator, often without the production of proper evidence. As a consequence, strong disagreements regarding scientific findings quickly escalate into *ad hominem* arguments against those conducting the research. Hard lines are drawn and further discussions become difficult if not impossible. While it is true that when there is smoke, there is often fire, the ability to fairly sort out the matter in a way that protects the rights of the accused is greatly compromised by such actions.

The IqC recognizes that some of the critics of bubble fusion have taken their case directly to the press rather than following the normal professional protocol of arguing the merits of the work in the peer reviewed literature. Furthermore, some of those who have lodged allegations against Taleyarkhan are not without their own self-interest in undermining his work. These issues did not distract the IqC. Our focus has been solely on the facts and evidence as we have determined them to the best of our ability.

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4. Executive Summary: Findings and Observations

This Inquiry Committee has given careful consideration to each of the allegations put before it, in light of all of the evidence provided by the principals involved both in support and in rebuttal. We restate that we have **NOT** been charged with the task of determining the veracity of claims related to D-D fusion in sonofusion. We respectfully leave this exercise up to the scientific community at large. To this end, a list of known sonofusion experiments that have come to the attention of the IqC is given in Appendix J. Our major concern has been evaluating the conduct, execution and reporting of work on sonofusion by Prof. R. Taleyarkhan since his arrival at Purdue University in the fall of 2003.

Findings

- The Inquiry Committee finds that it does not have jurisdiction to act on the following allegations: A1, A2, A3, A4, A5; B1, B2.
- The Committee finds that, at this time, the following allegations do not warrant further investigation by Purdue University as research misconduct based on the information currently available: C1, C4; D1; E2; F1, F3; G1, H1; I1; J1; M1, M2, M3, M4; N1.
- The Inquiry Committee finds that the following allegations warrant further investigation as provided by Purdue University Executive Memorandum C-22: C2, C3, C5, C6; D2, D3; E1, E3; F2; G2; K1; L1.

Observations

- Rusi Taleyarkhan has displayed a quality of scholarship inconsistent with that of a scientist of his experience and stature. We have pointed out numerous examples in this report of scholarship well below the standard widely practiced by members of the scientific community. Specific instances can be found in the discussion of allegations E1, E3, and G2, and in Appendices F, G, H, and J. The Dean of Engineering should review these instances and others described within this document regarding the quality of scholarship practiced by Taleyarkhan.

- Taleyarkhan has exhibited an apparent lack of willingness to be scientifically critical of his own data. Evidence supporting this viewpoint can be found in his responses to critics of his work cited here (Galonsky, Lipson, Naranjo, and Saltmarsh and Shapira) as well as in the transcript of his interview of July 23, 2007 with this Inquiry Committee.
- Rusi Taleyarkhan has not been fully responsive to this Inquiry Committee. Despite being given numerous opportunities to make full and complete disclosures on a number of issues, by both this and the previous Inquiry Committee, information has been forthcoming in piecemeal fashion. We refer

specifically to his involvement in the history of the *NED* and *NURETH-11* publications (Allegations C2, C3, C5: D2, D3; F2).

- The Inquiry Committee has concerns regarding Taleyarkhan's suitability for mentoring students, postdoctoral researchers and junior faculty. The College of Engineering and/or the Graduate School at Purdue University should perform its own investigation regarding Taleyarkhan's qualifications to serve as a graduate advisor. (Allegations C2, E3, I1, J1, K1)
- Many of the allegations presented to the Inquiry Committee are not well formulated; they are vague and lack credible substantiating evidence. In many cases and, to some degree, they were self-serving. It was left to the Inquiry Committee to determine what the real issues were in many cases. This took a considerable amount of time and unnecessarily delayed the entire process.

Table Summarizing Disposition of Allegations

Category	Allegations that will not advance
Reviewed by IqC	C1,C4,D1,E2,F1,F3,G1,H1,I1,J1, M1,M2,M3, M4, N1
No jurisdiction	A1,A2,A3,A4,A5,B1,B2

Category	Allegations that will advance to a C-22 Investigative Committee
Fabrication	
Falsification	C2,C3,C5,C6(contingent), D2,D3,F2,G2,K1,L1
Plagiarism	E1,E3,C6(contingent)
Practices that "seriously deviate . . . ."	

In a commentary titled "On analyzing scientific fraud,"[87] Braunwald eloquently writes about the investigation of scientific fraud and research misconduct. The written words still ring true since they succinctly summarize the grave task faced by this Committee.

> Just as it is incumbent on scientists to be meticulous about the manner in which they carry out their work, so is it incumbent on analysts of scientific behavior to be meticulous in their activities. Just as it is damaging to science to make exaggerated claims not

[87] E. Braunwald, Nature **325**, 15 January issue (1987).

> supported by data, so is it damaging to science to make exaggerated criticism and allegations about the conduct of science that are not fully supported by fact. Just as scientists must report the results of all relevant experiments and not select just those which support their conclusions while deleting those which do not, so should analysts of science adhere to the same rules.

The contents of Braunwald's article, especially the Conclusions, should be carefully read by all those who have closely followed this case.

5. Comments with Regards to the Nature and Form of Allegations

The IqC is charged under Executive Memorandum C-22 with information gathering and initial fact-finding to determine whether an allegation or apparent instance of research misconduct warrants an investigation. Critical to the success of any inquiry committee is the clarity exercised by those bringing forward allegations of research misconduct. Those desiring to submit charges of research misconduct should give considerable thought into which of the four possible categories of research misconduct each allegation falls. Following such categorization, explicit supporting evidence should accompany each charge.

The IqC was particularly struck by the fact that many of those submitting allegations had motivation to do so because of their own vested interest in the science of sonofusion. For example Putterman and Suslick are direct competitors of RT in the areas of sonofusion and sonoluminescense, respectively. This fact alone does not undermine the validity of their allegations. However, actions they have taken certainly call into question their motives. Such actions include:

- Confronting without prior notice Taleyarkhan, a collaborator on the ONR/DARPA grant, with the results of a simulation purporting to provide strong evidence that the published neutron spectrum (PRL **96**) arising from D-D fusion is really that of ^{252}Cf. This occurred during the March 1, 2006 visit of Putterman, Suslick and others. This is a highly unusual tactic to be taken by collaborators.
- The appearance of obvious collusion by Putterman and Naranjo with free-lance reporter, Eugenie Reich, who called RT on the very same day (March 1, 2006) shortly after the above confrontation requesting a response to Naranjo's claims. How could this be simply coincidental?

We also note a change in opinion among a number of the School of Nuclear Engineering faculty over the last few years regarding support for Taleyarkhan's sonofusion research. Some former supporters have recently lodged allegations to both the previous and the current IqC.

Appendix A – Abbreviations Used in This Report

Journals and Publications

MST – Multiphase Science and Technology
NED – Nuclear Engineering and Design
NURETH-11 – Proceedings of the 11th International Topical Meeting on Nuclear Reactor Thermal-Hydraulics
PRL – *Physical Review Letters*
PRE – *Physical Review E*

Names of People and Committees

IqC – Inquiry Committee
LT – Prof. Lefteri Tsoukalas
RT – Prof. Rusi Taleyarkhan
YX – Dr. Yiban Xu
PD – Prof. Peter Dunn

Detectors and radioactive sources referred to in various publications

NaI – sodium iodide
CR-39 – fast neutron track detector
TND – Thermal Neutron Detector
LS – Liquid Scintillator
Pu-Be – plutonium-beryllium
^{252}Cf – californium 252
BF_3 – boron-triflouride
LiI(Eu) – lithium iodide
PSD – Pulse Shape Discrimination
PZT – lead zirconate titanate, a piezoelectric material

Agencies

DOE – Department of Energy
ONR – Office of Naval Research
ORNL – Oak Ridge National Laboratory
ORISE – Oak Ridge Institute for Science and Education

Building Sites

RHPH G60 - Pharmacy Building room number where sonofusion research took place 2307

INOK – Facility in Lafayette, Indiana where sonofusion research took place after relocation from G60.

Scientific Societies

APS – American Physical Society