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## **Bubble Fusion Studies Vetted and Cleared by NED<sup>1</sup>**

A new paper\* on bubble fusion by the multi-institutional team composed of Taleyarkhan, Lapinskas, Xu, Cho, Lahey and Nigmatulin has been published by the international publishing house *Elsevier B.V.*, in the nuclear industry's premier flagship scientific journal *Nuclear Engineering and Design (NED)*.

The purpose of this new seminal paper is to clear up the misconceptions generated by the web-posting of the University of California at Los Angeles (UCLA) researchers and which was assumed as technically accurate and reported by *Nature* magazine in March, 2006. Over the past two years, a methodical and systematic study was undertaken with the intense efforts of researchers from Purdue University, Rensselaer Polytechnic Institute, Russian Academy of Sciences, FNC Tech. of S. Korea together with input from Dr. West (ret'd. ORNL). This study was documented, and using the time-honored traditions, then offered for anonymous peer review, acceptance and publication in *Nuclear Engineering and Design*. The manuscript has now been vetted using the time-honored acceptance process and accepted for archival publication in *NED*\*

The results of the new archival publication\* confirm for the record that the confusion and controversies caused from past reports have resulted from neglect of important details of bubble fusion experiments. The new results demonstrate that ice-pack shielding between the detector and the fusion source, gamma photon leakage and neutron pulse pileup due to picosecond duration neutron pulse emission during bubble fusion events play important roles in affecting the spectra of neutrons from acoustic inertial confinement thermonuclear fusion experiments.

The new paper presents a comprehensive unifying study for all six of the reported successful bubble fusion studies, including those associated with the successful confirmations by groups unaffiliated with the original Taleyarkhan et al. group. Two, unique, calibrated, validated and cross-checked methods were employed. Notably, in some of these successful bubble fusion experimental programs ice-pack shielding was present between the reactor and detector, while in others it was not. The goal was to address the confusion resulting from the misguided simulations for incorrect experimental configurations and omission of key physics of the bubble fusion phenomenon.

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<sup>1</sup> <http://authors.elsevier.com/offprints/NED5101/7cf7d2609f7b7995b711ac3e84956ae9>

On March 8, 2006 *Nature* magazine unfortunately published online an article by Eugenie Reich, “Bubble bursts for table-top fusion; Data analysis calls bubble fusion into question” doi:10.1038/news060306-3. This article relied on sources with undisclosed conflicts of interest from competitors. This misinformed article set into motion a federally (U.S. Congress and ONR) mandated investigation for over the past 2 years that was astonishingly based on a single unpublished, non-peer reviewed web-posting of Univ. California and Los Angeles (UCLA) researchers, chiefly by Brian Naranjo under the supervision of Seth Putterman (published in *Nature*). This web posting presented computer code simulation results for the anticipated neutron spectrum from the bubble fusion experiments of Taleyarkhan et al. (*PRL* 96, Jan. 2006). This simulation from UCLA researchers was conducted for a guessed (without fact checking) experimental geometry, along with their missing other attributes of bubble fusion phenomena in which neutrons of a fixed energy of 2.45 MeV from the bubble fusion nuclear reactor go whizzing past to a nearby detector with nothing in between. The calculated neutron spectrum of UCLA was shown to be very different from that published in the 2006 experimental report by Taleyarkhan et al. but it resembled the overall features of the neutron energy spectrum from Californium-252 (a commonly used laboratory radio-isotope which spontaneously emits neutrons over a range of energies and which most nuclear engineering laboratories possess, as was also the case with the Taleyarkhan et al. laboratory at Purdue University). This *Nature* article of March 8, 2006 then focused the world’s attention to imputed actions constituting fraud and bubble fusion data fabrication quoting UCLA’s B. Naranjo as stating: “The probability of getting such a poor match for neutrons produced by fusion is one in more than 100 Million – virtually impossible.” This verdict from a graduate student of UCLA based on a web-posting was then portrayed by the *Nature* reporter as true without accurate facts.

The resulting fallout was immense and extremely damaging to the team consisting of Taleyarkhan, Lahey, Nigmatulin, Block, West, Cho, and Xu, and importantly to the credibility of the field of bubble nuclear fusion, bringing it to a virtual halt. A federally-mandated multi-year investigation into dozens of allegations from worldwide groups has dismissed all allegations related to scientific fraud and fabrication, in the process supported the validity of the scientific discovery as presented to the world and it’s several successful replications. The remaining two (trumped up) allegations from Purdue University do not relate to the science and are clouded by institutional failures of Purdue University and will take years to resolve. While the remaining matters at Purdue University are hashed out, this will not change the future of bubble fusion.

“I can’t control the actions of the University in their unfortunate situation of having administrators and attorneys who place themselves ahead of the truth and importance of the science; this could happen to any other faculty member and is a sad precedent for the academic world. I can only move forward and remain positive,” Taleyarkhan said.

Upon careful examination by multiple researchers, it was found that the UCLA computer modeling omitted a simple but crucial physical parameter; i.e., the ~1-inch of ice pack (used as thermal shielding) placed between the bubble fusion reactor and the neutron detector in the experiments for the reported Taleyarkhan et al. 2006 PRL publication. Put simply, neutrons of a fixed energy generated from fusion flying through space are like bullets of a certain speed flying out from a gun. If one measures fusion neutrons without any intervening shielding the energy of the measured neutrons should be 2.45 MeV (the established energy if fusion were occurring), analogous to the (e.g., 1,000 fps) velocity of bullets from a given cartridge fired from a shotgun.

However, if one places a shield (composed of steel balls in a given spacing between them) between the gun and the target, some of the bullets will go through the holes while others will interact with the steel balls and slow down to various levels depending on the angle of attack, while others may stick to the balls or create fragments. The measured velocity of bullets leaving the shield will not be 1,000 fps but will range from ~0 to 1,000 fps. The same happens with neutrons flying through a shield composed of water molecules. Neutrons are sub-atomic particles and much smaller than the atoms of water. The neutrons (as in the bullet example) that come out of the water pack will not be of a fixed velocity (energy) either but must manifest themselves as neutrons having a range of energies; along with other nuclear scale effects, this sort of “neutron” (but not gamma) spectrum is deceptively similar to that from a radioisotope like Californium.

The UCLA researchers failed to include the ~1-inch of water (ice-pack) thermal shielding in their model “presuming” this absence, despite being admonished and alerted to do so otherwise; as a result, the mere omission of just an inch of water (along with the overlooking of other physics aspects of bubble fusion) has led to the premature, unfortunate and highly damaging suggestion of fraud as advertised to the world in *Nature*.

To date, the world has not witnessed a comprehensive 3-D study of the neutron transport processes associated with bubble fusion experiments. As a consequence, the UCLA results published as they were in the March 8, 2006 issue of *Nature* have been assumed as constituting factual evidence, but they were not.

**(\*)- Taleyarkhan, R.P., J. Lapinskas, Y. Xu, J. S. Cho, R. C. Block, R. T. Lahey, Jr., and R. I. Nigmatulin. Modeling, analysis and prediction of neutron emission spectra from acoustic cavitation bubble fusion experiments. Nucl.Eng.Des.(2008).doi:10.1016/i.nucengdes.2008.06.007.**

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