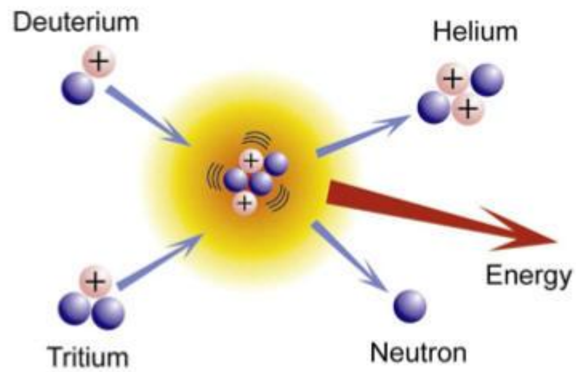
Quantum Fusion: Cavitation Induced Fusion

One of the branches of LENR /cold fusion research, is "Cavitation Induced Fusion".



Quantum Fusion is developing a reactor boiler to produce energy using this heat and light generating phenomena probably related to "Sonoluminescence". They recently gave a presentation at the ICCF 18 international LENR conference.

Steve Windischof from **The Free Energy Facebook Group** says "Its not clear at all if this process is directly related to the Pons and Fleischmann Effect or Nickel-Hydrogen Gas Loading (the two best known methods of LENR). But it does appear to have the ability to fuse Deuterium atoms to produce Helium isotopes; using the vast heat and pressures of collapsing bubbles in liquids."

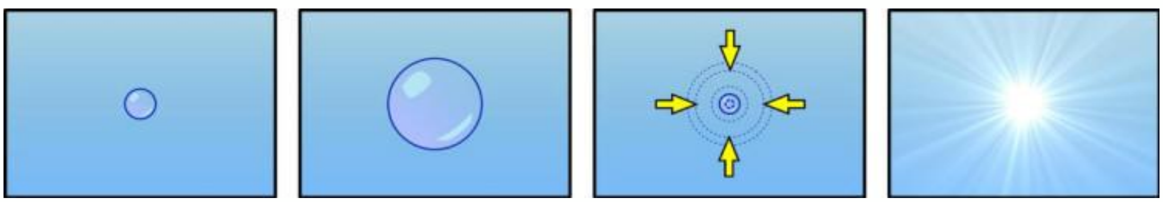
I decided to cover this story as I believe this effort if worthwhile following. There are some highly qualified people involved and I am sure it will spark a good debate in our comments section among our readers. I am way out of my depth of my here to comment on this from a scientific perspective. I will mainly rely on information from the website. I know some of the people involved personally and can vouch for their motives in this research project.

What is Cavitation Induced Fusion ?

Cavitation-induced fusion process is very simple: a cloud of fuel-filled bubbles is injected in a suitable carrier liquid and the bubbles are made to oscillate via a variable pressure drive. Properties of the liquid, dimensions and gas content of the bubbles as well as the characteristics of the pressure drive are engineered such that each bubble collapse results in mini-thermonuclear explosion with minuscule yield of just a few fusion reactions per collapse. However, due to large density of the bubbles and high frequency of the pressure drive a large amount of energy is released into the carrier liquid in a form of heat. The heat is removed by a heat exchanger and is used to produce steam driving a turbine that spins an electric A/C power generator. Alternatively, the heat can be used directly for heating, boiling, melting, etc. Overall design of a fusion power plant is little different from that of a conventional nuclear power plant.

Cavitation-Induced Fusion

The idea behind cavitation-induced fusion (also known as sonofusion or bubble fusion) stems from the phenomenon of sonoluminescence: when a liquid is excited with powerful acoustic waves, bubbles are formed due to acoustic cavitation; under the influence of the alternating acoustic pressure the bubbles periodically expand and collapse; the collapsing bubbles get so hot that hey give-off a bright flash of light.



Scientists studying sonoluminescence discovered that bubble core conditions resemble those found in stars: pressures in the range of thousands of atmospheres and temperatures in excess of 30,000K (or 5 times hotter than the surface of the sun) shave already been measured (Flannigan & Suslick, 2010). Theoretical modeling of bubble collapse predicts temperatures and densities sufficient for deuterium fusion when certain conditions are met (Moss, Clarke, White, & Young, 1996), (Bass, Ruuth, Camara, Merriman, & Putterman, 2008).

Rise and Fall of Bubble Fusion

Naturally, the possibility of attaining nano-scale thermonuclear fusion in the cores of collapsing bubbles in liquids was too good to be left unexplored. The first sonofusion U.S. Patent #4,333,796 was filed by Hugh Flynn in 1978. Dr. Seth Putterman (UCLA), world's leading authority on sonoluminescence obtained a U.S. Patent #5,669,173 for sonofusion device in 1997.

In 2002 Rusi Taleyarkhan and his colleagues at Oak Ridge National Laboratory (ORNL) have published a widely publicized paper (Taleyarkhan R. , West, Cho, Lahey, Nigmatulin, & Block, 2002), which described what was believed (albeit incorrectly) to be the first successful ‘bubble fusion’ experiment.

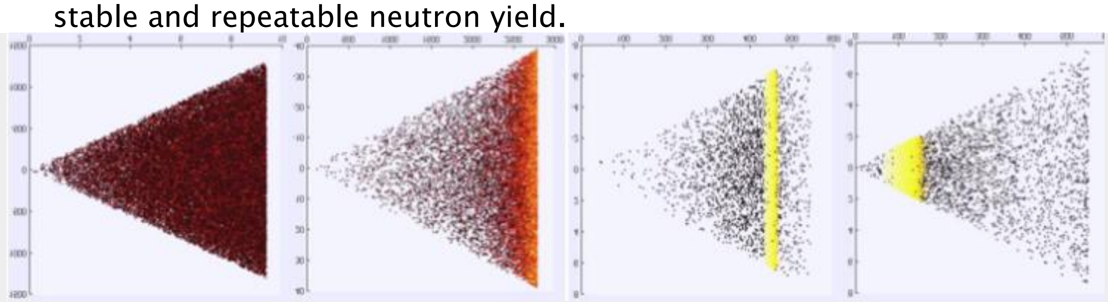
Unfortunately, their report (which appeared in Science) with follow-up papers published in Physical Review (Taleyarkhan, Cho, West, Lahey, Nigmatulin, & Block, 2004), stirred a hornet’s nest provoking all sorts of nasty developments ranging from academic rivalry, to conflict of interests in research funds appropriation (‘big fusion’ researchers felt threatened), to tenure and promotion issues and culminated with charges of academic misconduct (Krivit, 2011). As a result of the ensuing ‘bubblegate’ scandal Taleyarkhan’s career was destroyed (Reich, 2009) and sonofusion research became a taboo.

Successful Experiments

Not withstanding the scandal and the incorrect perception of the field as ‘bad science’, the following successful cavitation-induced fusion experiments have been performed and reported in peer-reviewed literature (Russian publications were never translated into English and therefore Russian/Soviet work is not widely known or cited in the West):

- Lipson et al., 1990 (USSR) studied cavitation in heavy water using an acoustic horn made from titanium. After a few hours of cavitation pits were formed on the horn’s surface and neutrons were detected. The authors argue that the fusion reactions were initiated by the cavitation bubble jets penetrating and compacting titanium deuteride layer formed on the horn’s surface.
- Taleyarkhan et al, 2002 (USA, ORNL) reported neutron emission when cavitation bubbles were created (using pulsed neutron generator) in chilled deuterated acetone. The paper was published in Science and is rightully considered to be the most influential paper on the subject.
- Xu et al., 2005 (USA, Purdue) published a confirmation or Taleyarkhan’s results by independently replicating the original ORNL experiment. However, because Xu was a former student of Taleyarkhan the independence of this replication was later contested.
- Taleyarkhan et al, 2006 (USA, Purdue) published another report indicative of nuclear fusion in cavitation bubbles in a mixture of acetone and benzene. This time the pulsed neutron generator was replaced with alpha-radioactive uranium salts dissolved in the mixture to address the criticism of the original ORNL effort, which was relying on an external pulsed neutron source to nucleate the cavitation bubbles.

- Forringer et al, 2006 (USA, Purdue) published a quasi-independent replication of Taleyarkhan's self-nucleated sonofusion experiment. This replication is not entirely independent because it was performed by Forringer during his visit to Taleyarkhan's lab at Purdue.
- Bugg et al., 2006 (USA, Purdue) published a similar report after repeating Taleyarkhan's experiment during his visit to Purdue.
- Bityurin et al., 2008 (Russia, Joint Institute for High Temperatures) has published an intriguing paper where heavy water with large (80% by volume) content of deuterium bubbles was subjected to a circular shock wave created by an exploding wire. The team measured a large neutron yield.
- Smorodov et al., 2008 (Russia) described a rather ingenious setup where a single 5-mm deuterium bubble in glycerol was crushed by a 1,000 bar shock producing stable and repeatable neutron yield.



Cavitation bubble collapse molecular dynamics modeling software achieves first results; we are able to model full bubble collapse, observe shock waver formation, and calculate bubble pressure from the first principles.

Our Approach

Our approach to bubble fusion (which we call cavitation-induced fusion or CIF) relies 100% on proven conventional straight-from-the-textbook science and has nothing to do with 'cold fusion' We owe our inspiration to papers byMoss, Clarke, White, & Young (1996) and especially by Bass, Ruuth, Camara, Merriman, & Putterman (2008). Researchers universally agree that large acoustic pressures (40-100 bar) are required to cause deuterium within cavitation bubbles to fuse. These large pressures are hard to achieve in an experiment. Fortunately, the problem of high pressure can be eliminated when the bubble content is engineered to lunch a converging shock wave when the bubble collapses. The focused shock allows achieving thermonuclear temperatures under much more modest pressures of 1-2 bars given proper choice of the carrier liquid and the bubble gas content. Additionally, instead of relying on acoustic cavitation where the liquid is vibrated by an ultrasonic transducer we rely on hydrodynamic cavitation where pressure waves within the liquid are created by the flow of the liquid itself. The latter approach can be made 90% efficient whereas conventional ultrasonic transducers are only ~ 10% efficient.

How do We Know There is Fusion?

There is a universal consensus among scientists that the following criteria needs to be met in order to establish conventional thermonuclear deuterium fusion unquestionably:

1. The experiment has be repeatable such that an independent third party group of researchers could easily replicate it;
2. There has to be a significant neutron emission statistically well above background level;
3. The neutron emission must coincide with the bubble collapse;
4. The energy spectrum of the detected neutrons must match the energy spectrum of neutrons produced in deuterium fusion;
5. Repeated fusion reactions will result in tritium production (tritium presence can be detected with a simple off-the-shelf test kit).

And last but not least there should **be no neutron sources in the laboratory** that can confuse the fusion neutron measurements.

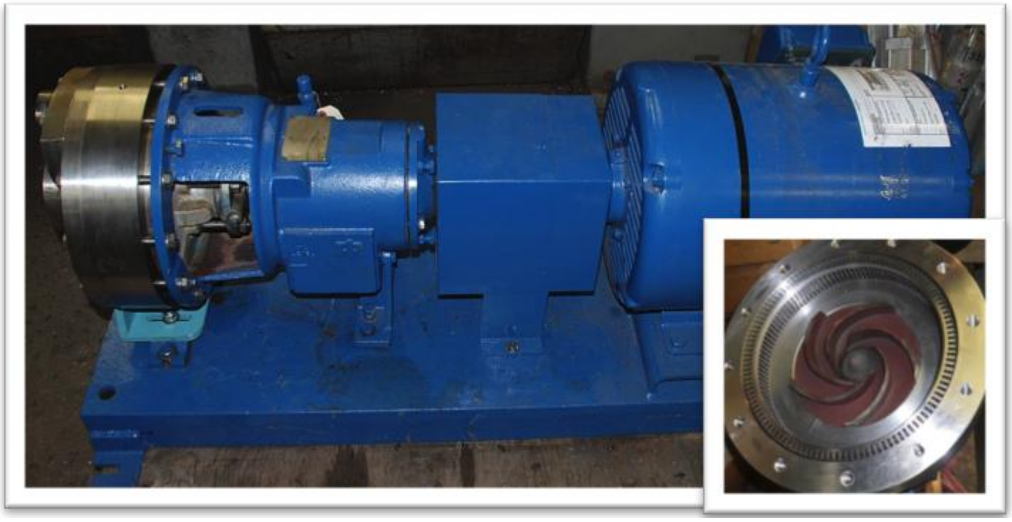
Our Experiments

We have conducted our own bubble fusion experiments, including a version of Taleyarkhan's multi-bubble sonofusion experiment performed under a different set of conditions. **We have detected neutron yield coincident with cavitation.**We are working on an improved version of this experiment that will satisfy the conditions 1-5.

Second generation commercial reactor prototype constructed and being prepared for testing on deuterium.

We have performed a version of Smorodov’s single-bubble fusion proof-of concept experiment and detected significant well-above-background neutron yield coincident with the impact. We are working on refining this experiment to where it can be used in a demonstration.

We have designed and built a hydrodynamic cavitation hardware according to Kladov (Kladov is a now deceased Russian nuclear engineer and cavitation technology expert). The machine is a modified centrifugal pump with perforated rotor and stator and it acts as a hydrodynamic siren. We are working on refining the design so we could achieve acoustic energy density on the order of 1 MW/m^2 that is necessary to achieve cavitation-induced fusion in this system. The machine is a work in progress and can serve as a basis for a commercial CIF generator.



Analytical Model

We have devised a complete analytical model for a collapsing deuterium bubble and programmed it in Wolfram Mathematica. The model incorporates solution to Rayleigh-Plesset-Keller (RPK) equation and accurate deuterium equation of state, which accounts for disassociation and ionization.

Molecular Dynamics Model

We have developed molecular dynamics software to model collapse of a gas bubble in liquid. The model allows us to estimating fusion yield and discovering a set of gas, liquid and pressure parameters that lead to the highest fusion yield.

Source: http://revolution-green.com/quantum-fusion-cavitation-induced-fusion/