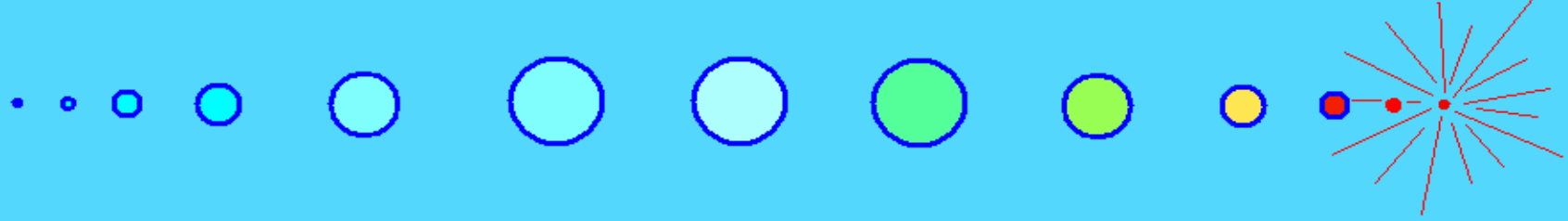


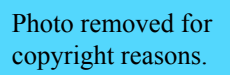
Acoustic Inertial Bubble Fusion! Confinement Fusion

Brian Kardon

2002:

At Oak Ridge National Laboratory in Tennesee,

this man, Rusi Taleyarkhan



published a paper that could produce an entirely new branch of fusion research,

and change the course of humanity.

(if it turns out to be correct)

Taleyarkhan's paper was entitled

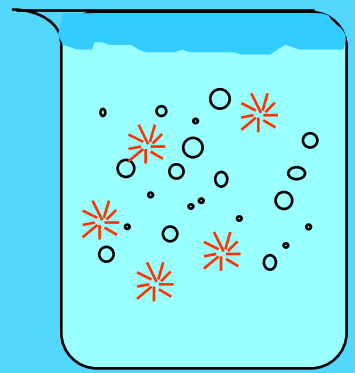
"Evidence for Nuclear Emissions During Acoustic Cavitation

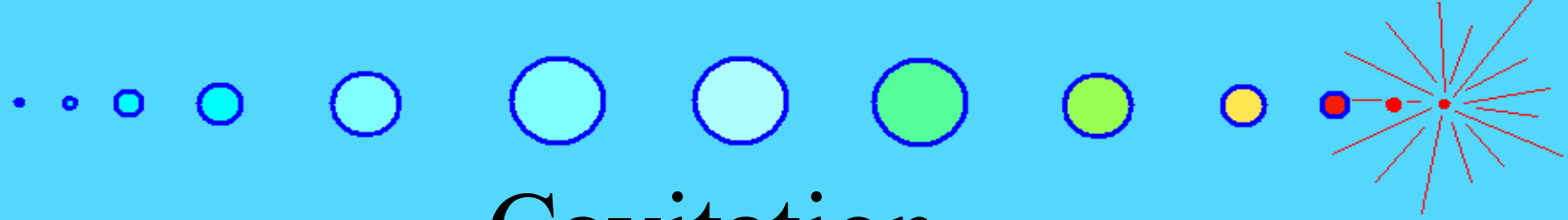
R. P. Taleyarkhan, J. S. Cho, C. D. West, R. T. Lahey, R. I. Rigmatulin, R. C. Block

(Science, 2002)

In which they describe success in their experimental goal:

to use sound to cause D-D nuclear fusion inside tiny bubbles in a glass beaker!





Cavitation

At the heart of Taleyarkhan's idea
is a phenomenon known as

"liquid cavitation"

Cavitation

What is it?

- Cavitation is the process in which vapor regions (bubbles) are formed in a liquid due to a local reduction in pressure below the vapor pressure.
- If the pressure rises after cavitation has occurred, the bubbles exhibit the unusual behavior of violently imploding!

Cavitation

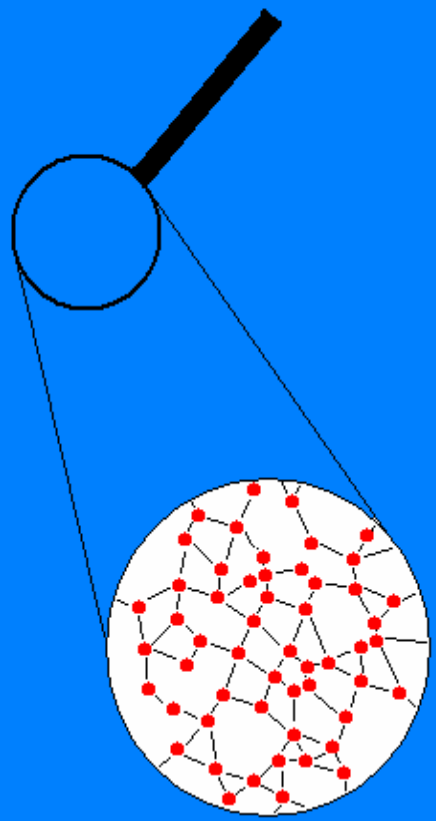
THE PROCESS:

Don’t take these too seriously;
they’re just to convey the basic idea.

Cavitation

THE PROCESS:

Step 0.

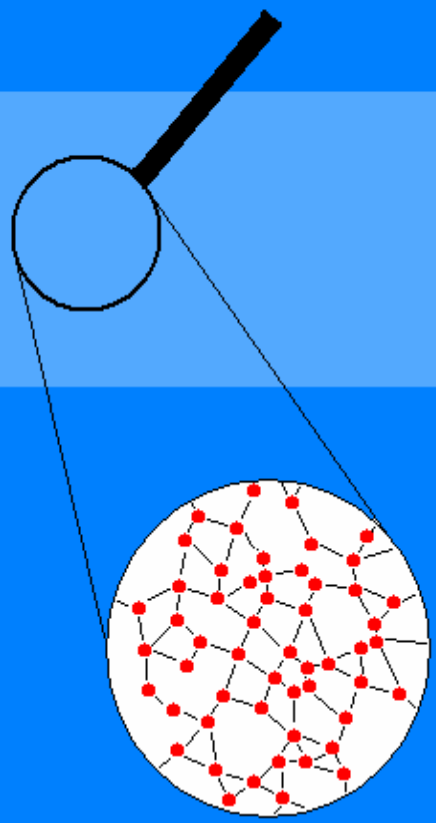


Cavitation

THE PROCESS:

Step 1. Low pressure zone

low pressure

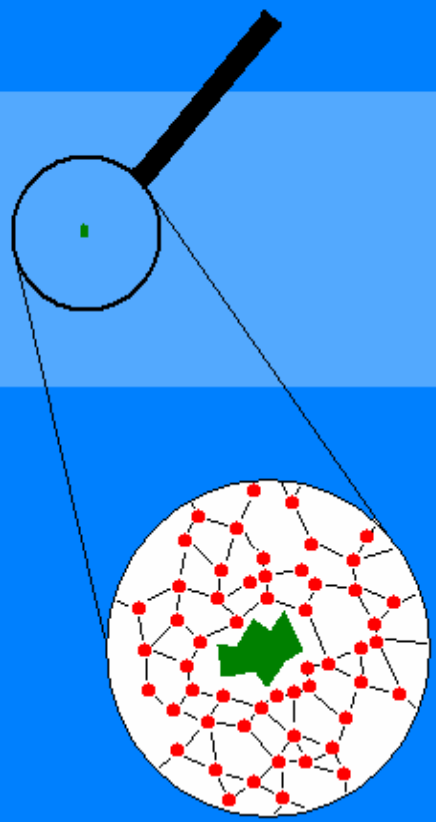


Cavitation

THE PROCESS:

Step 2. Nucleation

low pressure

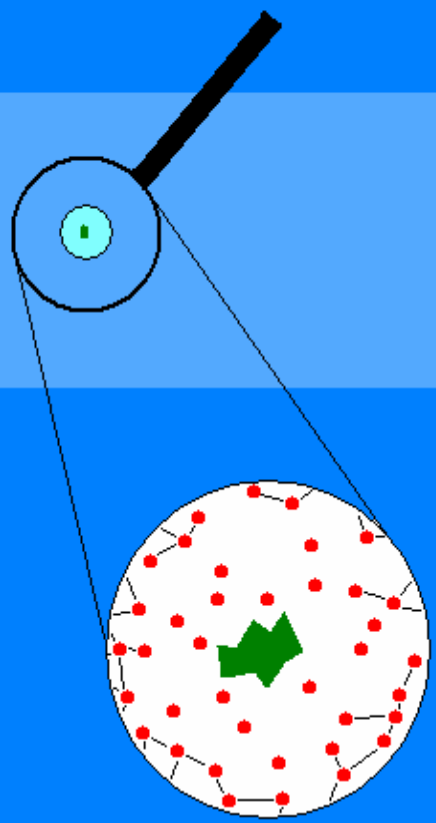


Cavitation

THE PROCESS:

Step 3. Bubble formation and growth

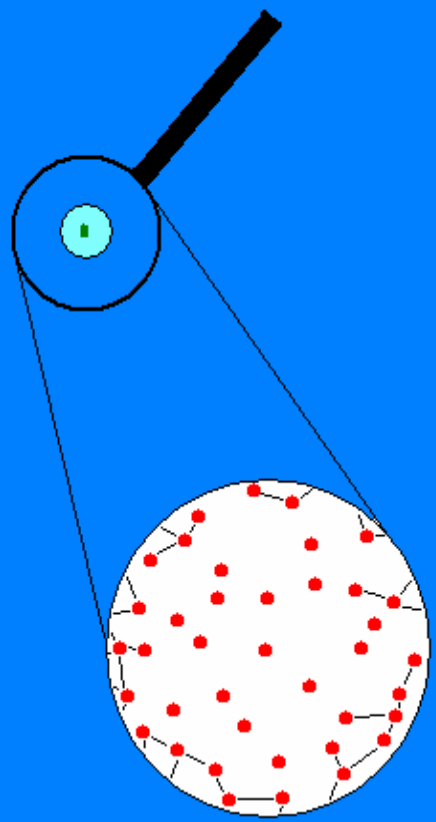
low pressure



Cavitation

THE PROCESS:

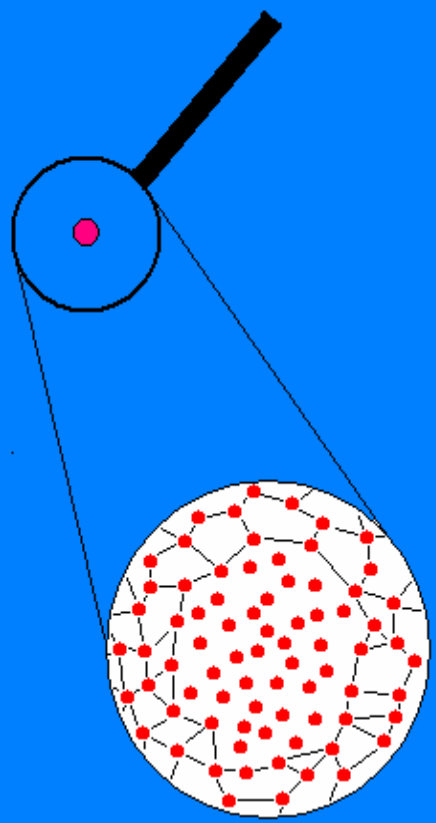
Step 4. Repressurization



Cavitation

THE PROCESS:

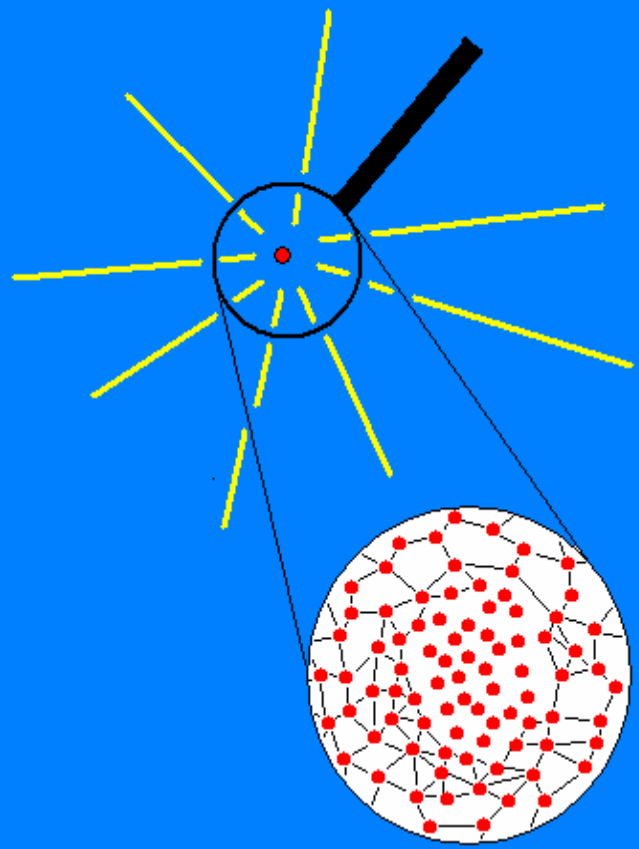
Step 5. IMPLOSION!!!

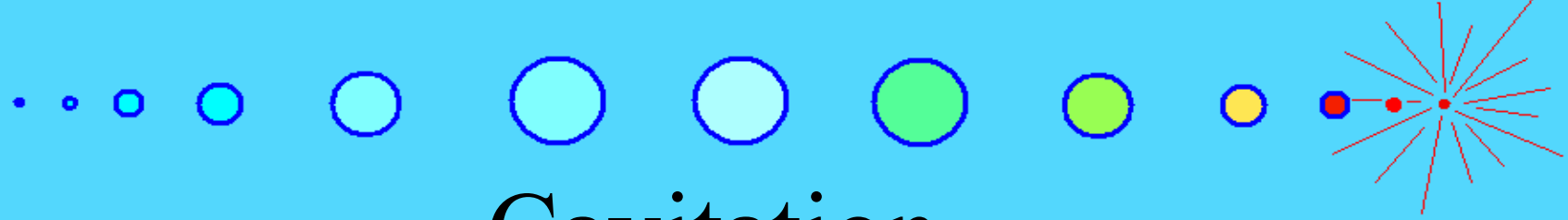


Cavitation

THE PROCESS:

Step 6. Luminescence, ionization?
FUSION???





Cavitation

- Cavitation is common wherever fast flowing liquid is found
- it occurs on the trailing edges of propellor blades and in certain regions of pipes
- it is used to precisely eject ink droplets in “bubblejet” printers
- it is thought to play a significant role in water erosion

Cavitation

cavitation streams from a propellor...

Courtesy of the U.S. Navy. Source: Wikipedia.

Cavitation

Photo removed for copyright reasons.
See Fig. 6.4 at http://caltechbook.library.caltech.edu/22/01/chap6.htm

damage from cavitation on a turbine

Cavitation

Photo removed for copyright reasons.
See Fig. 6.5 at http://caltechbook.library.caltech.edu/22/01/chap6.htm

damage from cavitation in a
spillway in the Hoover dam

Sonoluminescence

- An extreme case of cavitation
- Sound waves
  - Regions of alternating high and low pressure passing through a medium
- When high-frequency (~20 kHz), high amplitude sound passes through a liquid, it can induce cavitation that is so violent that upon implosion, the vapor inside the bubbles is heated to incandescence!

Sonoluminescence

Photos removed for copyright reasons.

Video may be found at
http://stilton.tnw.utwente.nl/shrimp/artist.html

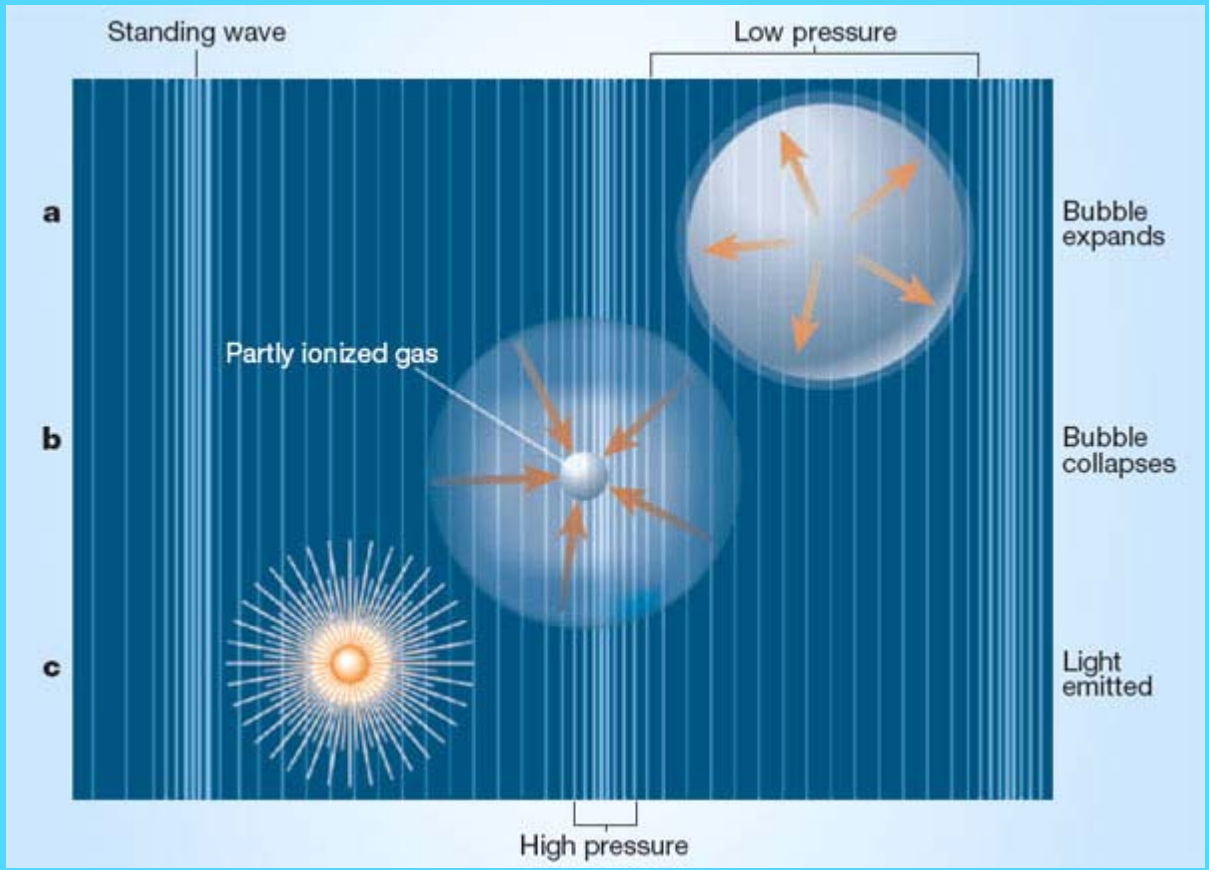
Image removed for copyright reasons.
Photograph of a pistol (snapping) shrimp.
See: http://stilton.tnw.utwente.nl/shrimp/shrimpphoto.jpg

disclaimer: this is not sonoluminescence :(

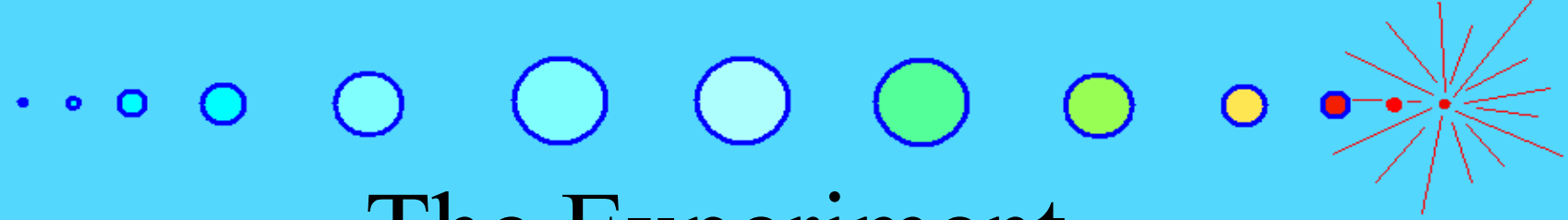
Pistol shrimp - note the augmented right claw

Sonoluminescence

A cartoon of sonoluminescence



Courtesy of Detlef Lohse. Used with permission.



The Experiment

- Cylindrical pyrex beaker
- 99.92% pure degassed deuterated acetone (C_3D_6O) @ 0 C
- Lead-zirconate-titanate (LZT) piezoelectric driver, driving acetone at 19.3 kHz, amplitude 15 bar
- Pulse Neutron Generator - 14 MeV @ 200 Hz
- Photomultiplier tube (light emissions) and liquid scintillator (neutrons, gamma rays)

The Experiment:

Photo removed for copyright reasons. See Fig. 2(a) in Taleyarkhan (2004).

The Experiment

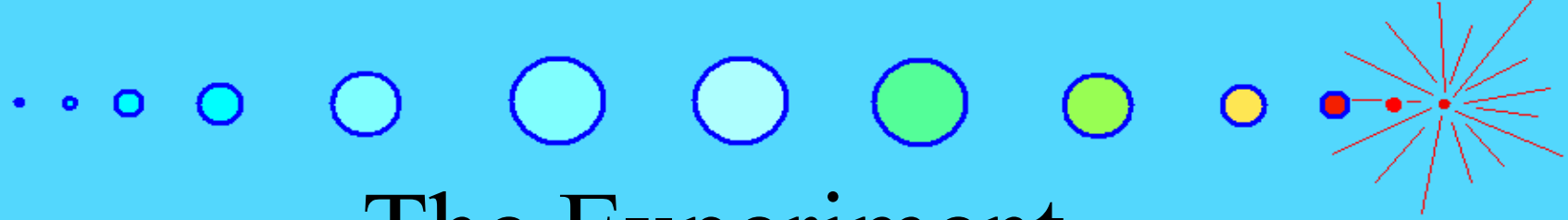
The experimental design:

Taleyarkhan controlled the experiment by repeating the process with combinations of:

C_3D_6O / C_3H_6O

with / without cavitation

with / without neutron pulses



The Experiment

How could their results show they were doing fusion?

- With (C_3D_6O, cavitation, PNG):
  - Emitted neutrons are at the right energy and coincident with sonoluminescence
  - Tritium production
- Without one of (C_3D_6O, cavitation, PNG):
  - No detection of fusion-generated neutrons
  - No tritium surplus

Tritium Count

The Results!

Figure removed for copyright reasons. See Fig. 11 in Taleyarkhan (2004).

(error bars are 1SD)

Neutron Count

The Results!

Figure removed for copyright reasons. See Fig. 4 in Taleyarkhan (2002).

The Results

"Typical" coincidence result for neutron, SL, and acoustic detection

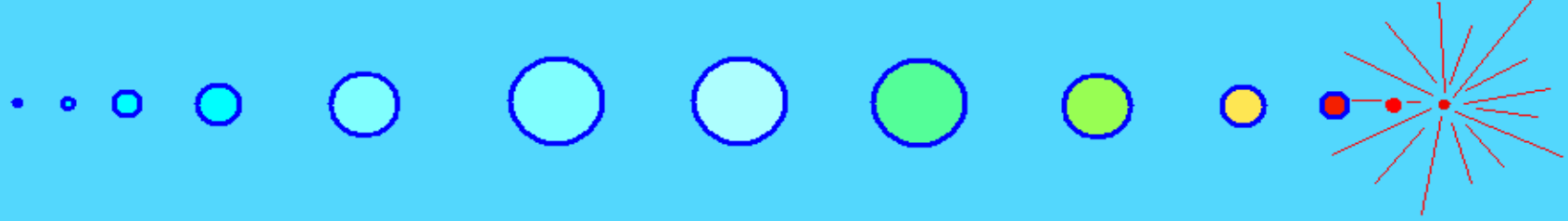
Figure removed for copyright reasons. See Fig. 5(a) in Taleyarkhan (2002).

The Results!

- No neutrons or tritium increase from background levels was detected in any control experiments (without deuterium, cavitation, or neutron nucleation)
- **D-D fusion-like neutrons and significantly increased tritium levels were detected in full experimental setup!!!**

The Results!

- When all parameters were positive
  - Tritium count increased by 15 cpm above baseline (2.5 SD)
  - <2.5 MeV Neutron count increased by 4% over (~4SD) non-cavitating levels
- These effects were not statistically observed when one or more parameters were negative.

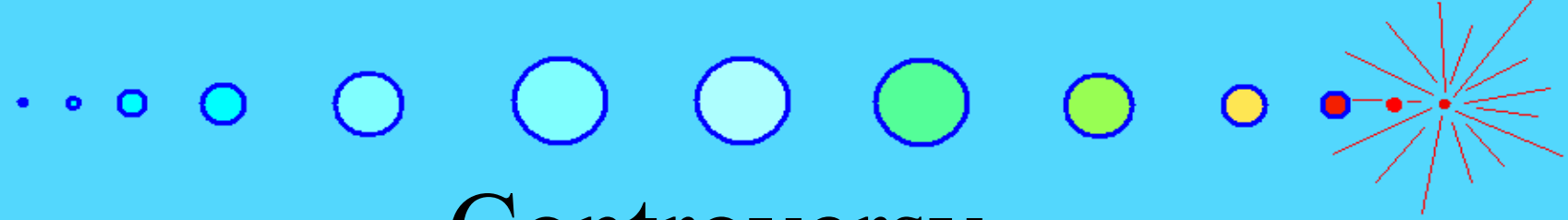


"The observation of statistically significant T activity increases only in chilled (~0°C) cavitated C3D6O, coupled with evidence for neutron emissions in chilled cavitated C3D6O, and the absence of neutron emissions and T production in irradiated control tests with C3H6O, complemented by confirmatory modeling and HYDRO code simulations, suggest the possibility of D-D fusion during acoustic cavitation experiments with C3D6O"

- Taleyarkhan et al.

Controversy

- Desktop fusion has been a touchy subject since the 1989 fiasco
- Some people within ORNL and within Science tried to stop the publication
- Another group within ORNL quickly followed up with an attempt to repeat the experiment.



Controversy

"Nuclear Fusion in Collapsing Bubbles—Is It There? An Attempt to Repeat the Observation of Nuclear Emissions from Sonoluminescence"

-D. Shapira and M. Saltmarsh (ORNL)

"Using the same cavitation apparatus, a more sophisticated data acquisition system, and a larger scintillator detector, we find no evidence for 2.5-MeV neutron emission correlated with sonoluminescence form collapsing bubbles."

Controversy

Shapira and Saltmarsh found

- No significant neutron count increases
- No significant neutron-SL coincidences
- Tritium levels…not measured.

Rebuttal

Taleyarkhan & co were not deterred; they thanked Shapira and Saltmarsh for the scientific criticism, and repeated the experiment.

Rebuttal

Additional evidence of nuclear emissions during acoustic cavitation

2004, American Physical Review

“Additional evidence of nuclear emissions during acoustic cavitation”

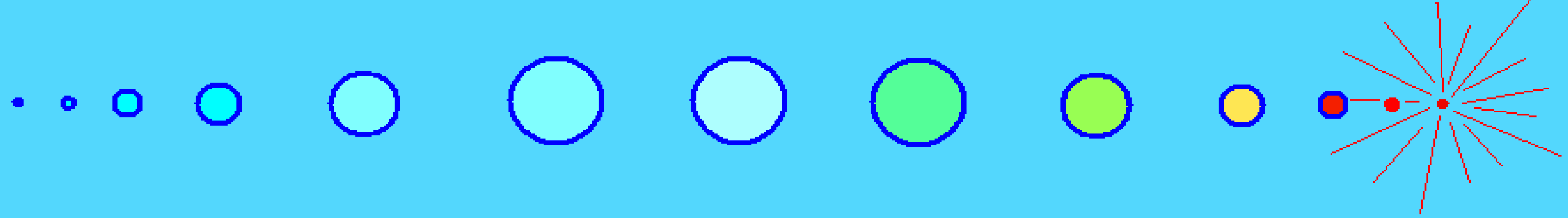
R. P. Taleyarkhan, J. S. Cho, C. D. West, R. T. Lahey, R. I. Rigmatulin, R. C. Block

In which they describe a successful repetition of the initial experiment, with better equipment

and cooler graphs too.

Second Results

Figure removed for copyright reasons. See Fig. 4 (a) and (b) in Taleyarkhan (2004).



Second Results

Figure removed for copyright reasons. See Fig. 7 (c) in Taleyarkhan (2004).

Second Results

Essentially the same as before!

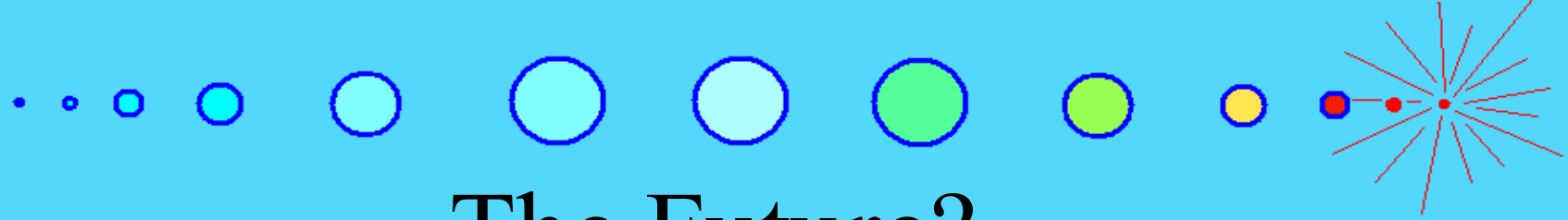
Taleyarkhan's group's reported tritium levels, neutron data, etc, all confirm the results of their first paper.

Mixed News

Another Purdue group, Yiban Xu and Adam Butt, reported that they had duplicated Taleyarkhan's results with essentially the same apparatus!

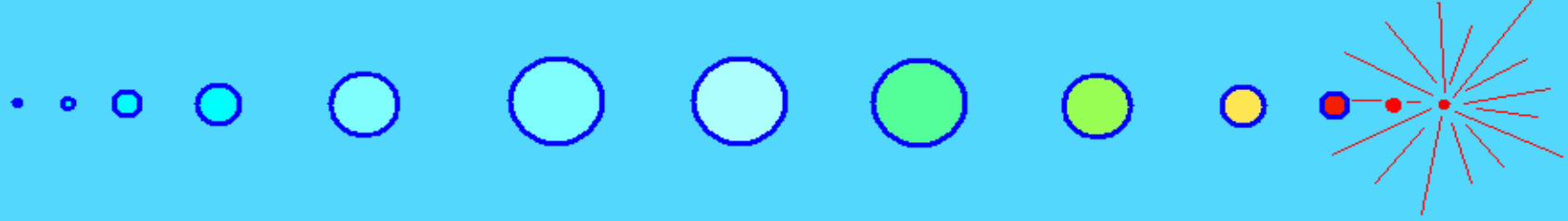
In May, 2006, Purdue began an investigation into Taleyarkhan's work, with hints of a fraud investigation.

The investigation is still pending.



The Future?

- Taleyarkhan may be found guilty of fraud, or simply bad experimental procedure
  - Alternative fusion science gets another nasty kick in the butt
  - Acoustic cavitation research benefits
- Taleyarkhan is vindicated!
  - $$$ flow into AIC research to try to achieve break-even, and possibly humanity is provided with limitless energy
  - Everyone lives happily ever after.



watch the news!!

Thanks for listening!

Sources

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