Sonofusion Experiment Produces Results Without External Neutron Source

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A team of researchers from Rensselaer Polytechnic Institute, Purdue University, and the Russian Academy of Sciences has used sound waves to induce nuclear fusion without the need for an external neutron source, according to a paper in the Jan. 27 issue of *Physical Review Letters*.

The results address one of the most prominent questions raised after publication of the team's earlier results in 2004, suggesting that "sonofusion" may be a viable approach to producing neutrons for a variety of applications.

By bombarding a special mixture of acetone and benzene with oscillating sound waves, the researchers caused bubbles in the mixture to expand and then violently collapse. This technique, which has been dubbed "sonofusion," produces a shock wave that has the potential to fuse nuclei together, according to the team.

The telltale sign that fusion has occurred is the production of neutrons. Earlier experiments were criticized because the researchers used an external neutron source to produce the bubbles, and some have suggested that the neutrons detected as evidence of fusion might have been left over from this external source.

"To address the concern about the use of an external neutron source, we found a different way to run the experiment," says Richard T. Lahey Jr., the Edward E. Hood Professor of Engineering at Rensselaer and coauthor of the paper. "The main difference here is that we are not using an external neutron source to kick the whole thing off."

In the new setup, the researchers dissolved natural uranium in the solution, which produces bubbles through radioactive decay. "This completely obviates the need to use an external neutron source, resolving any lingering confusion associated with the possible influence of external neutrons," says Robert Block, professor emeritus of nuclear engineering at Rensselaer and also an author of the paper.

The experiment was specifically designed to address a fundamental research question, not to make a device that would be capable of producing energy, Block says. At this stage the new device uses much more energy than it releases, but it could prove to be an inexpensive and portable source of neutrons for sensing and imaging applications.

To verify the presence of fusion, the researchers used three independent neutron detectors and one gamma ray detector. All four detectors produced the same results: a statistically significant increase in the amount of nuclear emissions due to sonofusion when compared to background levels.

As a cross-check, the experiments were repeated with the detectors at twice the original distance from the device, where the amount of neutrons decreased by a factor of about four. These results are in keeping with what would be predicted by the "inverse square law," which provides further evidence that fusion neutrons were in fact produced inside the device, according to the researchers.

The sonofusion debate began in 2002 when the team published a paper in Science indicating that they had detected neutron emissions from the implosion of cavitation bubbles of deuterated-acetone vapor. These data were questioned because it was suggested that the researchers used inadequate instrumentation, so the team replicated the experiment with an upgraded instrumentation system that allowed data acquisition over a much longer time. This led to a 2004 paper published in Physical Review E, which was subsequently criticized because the researchers still used an external neutron source to produce the bubbles, leading to the current paper in Physical Review Letters.

The latest experiment was conducted at Purdue University. At Rensselaer and in Russia, Lahey and Robert I. Nigmatulin performed the theoretical analysis of the bubble dynamics and predicted the shock-induced pressures, temperatures, and densities in the imploding bubbles. Block helped to design, set up, and calibrate a state-of-the-art neutron and gamma ray detection system for the new experiments.

The research team leaders are all well known authorities in the field of nuclear engineering. Lahey is a fellow of both the American Nuclear Society (ANS) and the American Society of Mechanical Engineers (ASME), and is a member of the National Academy of Engineering (NAE). Block is the longtime director of the Gaerttner Linear Accelerator (LINAC) Laboratory at Rensselaer, and he is also a fellow of the ANS and recipient of their 2005 Seaborg Medal, which recognizes an individual who has made outstanding scientific or engineering research contributions to the development of peaceful uses of nuclear energy. Taleyarkhan, a fellow of the ANS and the program's director, is currently the Ardent Bement Jr. Professor of Nuclear Engineering at Purdue University. Nigmatulin is a visiting scholar at Rensselaer, a former member of the Russian Duma, and the president of the Bashkortonstan branch of the Russian Academy of Sciences (RAS).

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