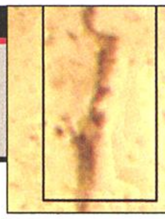

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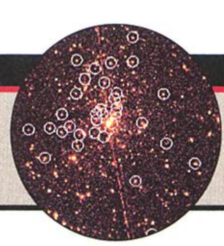
Death sentence for earliest life?



1813
A flare for the spectacular

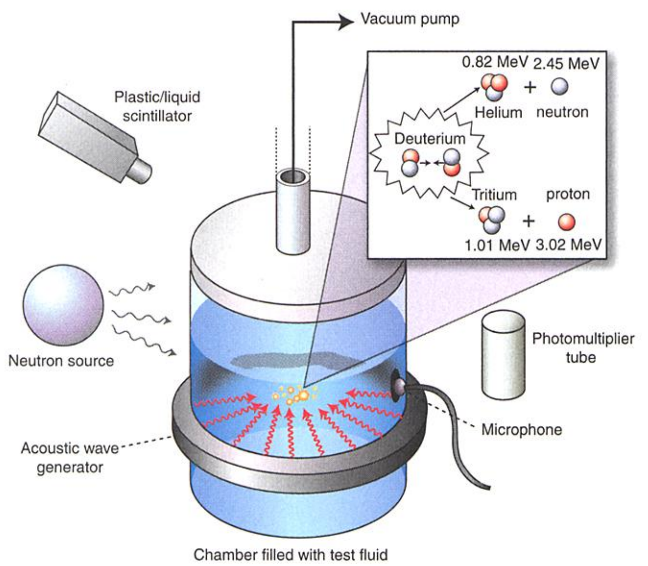
NUCLEAR FUSION

'Bubble Fusion' Paper Generates A Tempest in a Beaker

The heat from the controversy alone is nearly enough to trigger a nuclear reaction. This week in *Science* (p. 1868), scientists led by nuclear engineer Rusi Taleyarkhan of Oak Ridge National Laboratory in Tennessee claim to have seen evidence for nuclear fusion in a beaker of organic solvent. That stunning claim, if true, could eventually have important consequences for nuclear proliferation and energy production. But other scientists, citing another Oak Ridge experiment that seems to belie the claim, are likening the paper to cold fusion. Adding to the brouhaha is a series of exchanges between the magazine's editor-in-chief and nonauthors seeking to influence *Science* during its publication of the paper.

Unlike nuclear fission, fusion is very difficult to initiate. Only at extremely high pressures and temperatures can atomic nuclei slam together hard enough to merge, or fuse, releasing energy in the process. A hydrogen bomb achieves those pressures by first setting off a small fission bomb to get the process going. A handful of labs are gearing up to do the same with enormous lasers or powerful magnetic fields (*Science*, 18 August 2000, p. 1126; 25 January 2002, p. 602). Small-scale "tabletop" fusion reactions, meanwhile, have remained far out of reach. And the scientific community is still wiping egg off its face from the 1989 debacle involving so-called cold fusion, in which some researchers erroneously claimed to have seen fusion catalyzed by a lump of palladium metal.

It is against this backdrop that Taleyarkhan, nuclear engineer Richard Lahey of Rensselaer Polytechnic Institute in Troy, New York, and colleagues make their case for tabletop fusion. The work relies on a phenomenon known as acoustic cavitation, in which sound waves rattling through a fluid create tiny bubbles and then cause them to expand and compress. Under certain conditions, those bubbles give off tiny flashes of light as they collapse, a phenomenon known as sonoluminescence. Many scientists believe that the bubbles, compressed by the acoustic waves, reach great temperatures and pressures. Some speculate that under the right conditions, those bubbles might—just might—provide conditions extreme enough to trigger fusion.



Pop! Embattled paper suggests that deuterium nuclei undergo fusion inside sonoluminescent bubbles.

ILLUSTRATION: C. SLAYDEN

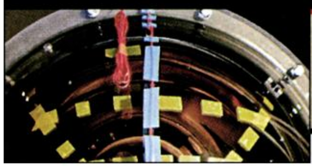
Taleyarkhan and colleagues set out to test that idea. Starting with a small cylinder of acetone in which all the hydrogen atoms had been replaced with deuterium (a heavy breed of hydrogen that has an extra neutron), the team subjected the cylinder to acoustic waves. At the same time, they zapped the deuterated acetone with high-speed neutrons. The neutrons, which each carried about 14 million electron volts (MeV) of energy, struck the molecules of acetone and gave them a punch of energy. "You get vaporization on a small scale," says Taleyarkhan. The pockets of vapor nucleate bubbles and cause them to grow to about 1 millimeter across—much bigger than they would normally get in an acoustic field. "They grow to be mammoths," he says. "You can actually see the bubbles."

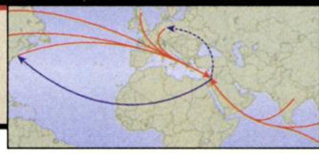
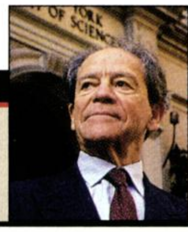
The catastrophic collapse of a millimeter-sized bubble to a few nanometers across heats the deuterated acetone to the point at which deuterium atoms collide and fuse, the authors argue. "I thought, doggone! I'm depressed I hadn't done that experiment," says Lawrence Crum, a sonoluminescence expert at the University of Washington, Seattle, who acknowledges that he reviewed the paper for *Science*. (The magazine's editors do not reveal the identities of reviewers to *Science*'s news staff.)

When deuterium fuses with deuterium, two equally probable things can happen. First, the two can form an atom of hydrogen-3, or tritium, while the extra proton zooms off with about 3.02 MeV (and in the apparatus would be quickly absorbed by the acetone). On the other hand, the two can make a helium-3 nucleus, while the extra neutron flies off with 2.45 MeV; unlike the proton, it would escape the acetone bath. Taleyarkhan and his colleagues claim to have detected neutrons whose energies are consistent with 2.45-MeV emissions, and they also claim to have seen extra tritium in the solution. Both effects disappear when they replace deuterated acetone with acetone, turn off the acoustic waves, or change the temperature of the bath to make it less favorable for cavitation.

Some physicists have greeted the work with deep skepticism. "The paper's kind of a patchwork, technically, and each of the patches has a hole in it," says Mike Moran, a physicist at Lawrence Livermore National Laboratory in California who has performed similar experiments with deuterated water. Moran says electromagnetic interference by an acoustic-wave generator raised false hopes of fusion in his own lab, and he worries that something similar may have happened at Oak Ridge. A beaker full of deuterated acetone, he says, should show an increase in tritium when irradiated by fast neutrons, even without cavitation—whereas Taleyarkhan's data show an enhancement only while the solution is cavitating. "It's an inconsistency in the data," according to Moran.

Tougher criticism comes from Dan Shapira and Michael Saltmarsh, two physi-



cists who are also at Oak Ridge. Late in May, after the lab had given Taleyarkhan and colleagues the go-ahead to submit their results to *Science*, Lee Riedinger, the lab's deputy director for science and technology, asked Shapira and Saltmarsh to check the work with a more sensitive neutron detector.


Deuterated duo. Rusi Taleyarkhan (*left*) and Richard Lahey hope others will soon repeat their experiment.

They concluded that Taleyarkhan's results had been an illusion.

"There's no evidence for any neutron excess due to fusion," Saltmarsh says. "If the tritium results in Taleyarkhan's paper are correct, and if you assume all the tritium is due to d-d fusion, then you expect a 10-fold increase in the neutron signal. We see a 1% effect." One possibility is that the extra neutrons are left over from the 14-MeV neutrons fired into the cylinder, eventually winding up in the detector after skittering about the room. To rule out that scenario, says Saltmarsh, he and Shapira timed the flashes of light from the bubbles and compared them with the arrival times of the extra neutrons. The effect disappeared. "We didn't see any evidence for a coincidence between neutrons, gamma rays, and light emissions above background," Saltmarsh says.

Taleyarkhan and colleagues dispute Saltmarsh's interpretation of the data and are posting the details of their objections on the Web. Riedinger characterizes the ongoing dispute as "an active dialogue about what could be wrong with either set of measurements." At the same time, he compliments Taleyarkhan's abilities and calls the work "very novel and interesting."

Sharper comments began to pepper *Science*'s editors as Taleyarkhan's paper neared publication. Don Kennedy, the editor-in-chief of *Science*, says that Oak Ridge officials tried to withdraw their permission to publish the paper. "There was certainly pressure from Oak Ridge to delay, if not to kill, the paper," says Kennedy. "I'm annoyed at the intervention, and I'm annoyed at the assumptions that nonauthors had the authority to tell us we couldn't publish the paper."

As knowledge of the pending paper spread, scientists outside Oak Ridge joined the fray. Late in February, physicist William Happer of Princeton University and Richard Garwin of IBM's Thomas J. Watson laboratory in Yorktown Heights, New York, each wrote Kennedy a letter about the paper. They say they were simply encouraging *Science* to publish the Shapira and Saltmarsh data as well, or at least not to hype the paper.

"I like *Science*," Happer says. "I'm a member of AAAS, and I don't want them to shoot themselves in the foot—or some other body part. All I told [Kennedy] was, for God's sake, don't put it on the cover." Happer, who headed the Department of Energy's science office for 2 years in the early 1990s, adds that he is also trying to save the scientific community from another embarrassing fiasco. "I saw it happen with cold fusion. If we're really unlucky, Dan Rather will talk about it on the [CBS] evening news and intone how, providentially, the energy problem has been solved. We as a community will look stupid."

Garwin says that he was troubled by the quality of the research. The version of the paper he saw described how the authors constantly adjusted the experimental setup to keep it tuned properly—conditions ripe for allowing unconscious bias to seep into the data. Given these concerns, he says, "it would be unfortunate if *Science* magazine were to take any position on its correctness."

Kennedy says that publication in *Science* certifies only that Taleyarkhan's paper has cleared the magazine's own peer-review and editing process. After that, it's up to the scientists. "We're not wise enough to certify that every claim will stand up to the active effort of replication," says Kennedy.

The importance of replication, apparently, is one of the few things on which everybody can agree. "There's some small chance that they're right," says Happer. "It should be published. The truth always comes out." Taleyarkhan takes the same position, although he hopes for the opposite result. "I'm looking forward to helping people reproduce the experiment," he says. But until then, confusion, not fusion, is likely to reign.

—CHARLES SEIFE

CREDIT: (BOTTOM) AMY HISE

INFECTIOUS DISEASE

New Culprit Emerges In River Blindness

For decades, people have blamed a parasitic nematode for a disease that has blinded at least 250,000 people now living in Africa and South America. But the real culprit—or at least an accomplice—may be the ubiquitous *Wolbachia*, bacteria that colonize many hundreds of species, including the nematode indicted in river blindness.

On page 1892, researchers report that *Wolbachia* stimulate the severe immune system response that slowly robs people of their vision in areas where the disease is endemic. The work "is one of the most exciting things that's happened in the past 10 years" in research on parasitic nematodes, comments Jan Bradley, a parasitologist at the University of Nottingham, United Kingdom. It "sheds a different light on the pathology of this disease," and it has already sparked debate about how big a role this bacterium really plays.

River blindness begins with repeated bites from black flies that are common along rivers and streams in tropical areas. The insects transmit nematode larvae that settle under the skin, mature, and produce millions of young larvae called microfilaria. Those of the species *Onchocerca volvulus* travel through the skin to the eyes, where they remain in the microfilaria stage and die after about a year. A victim of the disease can have "hundreds of worms wiggling in the eye," says Bradley.


Occupied territory. *Wolbachia* (red) thrive in the filarial worms blamed for river blindness.

Parasitologists have long assumed that the nematodes cause the inflammation that damages the eyes and cornea, probably by