

The New York Times

Science

April 8, 2003

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New Fusion Method Offers Hope of New Energy Source

By KENNETH CHANG

PHILADELPHIA, April 7 — With a blast of X-rays compressing a capsule of hydrogen to conditions approaching those at the center of the Sun, scientists from Sandia National Laboratories reported today that they had achieved thermonuclear fusion, in essence detonating a tiny hydrogen bomb.

Such controlled explosions would not be large enough to be dangerous and might offer an alternative way of generating electricity by harnessing fusion, the process that powers the Sun. Fusion combines hydrogen atoms into helium, producing bountiful energy as a byproduct.

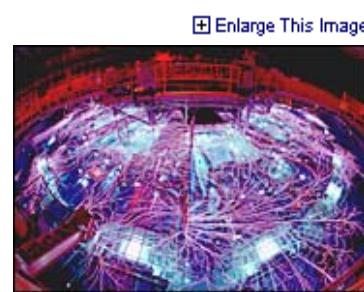
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Randy Montoya/Sandia National Laboratories

Sandia used its 104-foot-wide Z accelerator to gather a large amount of energy and unleash it on hydrogen, producing a small fusion reaction.

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"It's the first observation of fusion for a pulsed power source," said Dr. Ramon J. Leeper, manager of the target physics department at Sandia, in Albuquerque, who presented the findings at a meeting of the American Physical Society here.

Fusion power would be safer than fission, the current method used in nuclear power plants, because fusion does not produce long-lived radioactive waste.

Most fusion efforts have tried to use magnetic fields to compress hydrogen to temperatures hot enough for fusion to occur continuously, as it does in the Sun. But sustaining a dense hot cloud of hydrogen gas has proved trickier than scientists thought when they started fusion

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experiments 50 years ago. Even proponents say decades of research and expensive reactors are needed before a commercial power plant is possible. Dr. Jeff Quintenz, director of the Pulsed Power Sciences Center at Sandia, likened the approach to burning coal in a furnace.

The Sandia experiments, by comparison, could lead to something more like an internal combustion engine, in which power is generated through a series of explosions. "Squirt in a little bit of fuel, explode it," Dr. Quintenz said. "Squirt in a little bit of fuel, explode it."

That approach is potentially simpler, eliminating the need to confine hot hydrogen gas. But designing a machine that could detonate controlled thermonuclear explosions in quick succession — and survive them — is an engineering challenge that scientists have only begun to think about.

Earlier, scientists at Lawrence Livermore National Laboratory in California set off fusion explosions by shining intense lasers on hydrogen capsules. Livermore plans to further that research in a new National Ignition Facility. Other scientists are looking to implode hydrogen with beams of heavy elements like xenon or cesium.

The Sandia apparatus, the Z accelerator, was originally built to study nuclear weapons explosions without actual nuclear tests. In the mid-90's, the Z accelerator put out an impressive 20 trillion watts of X-rays. But that was far short of what is needed to induce fusion, and Sandia officials considered turning it off.

Improvements have raised the peak X-ray power by a factor of 10, to more than 200 trillion watts. It has been considered a dark-horse candidate for practical fusion. "We are solidly in the fusion regime," Dr. Quintenz said. "We're in the game."

For a few billionths of a second, the power of the X-rays crashing into the hydrogen capsule far exceeds the output of all the world's power plants.

Most of the 104-foot-wide machine, which resembles a large wagon wheel, stores a large amount of electrical energy, enough to power 100 houses for two minutes, and unleashing it quickly, which sets off a Rube Goldberg chain of events that leads to fusion. At the center of the machine are 360 vertical tungsten wires that form a cylindrical cage one and a half inches across. Inside the cage is a plastic foam cylinder. Encased in the foam is a BB-size plastic capsule that holds deuterium, a heavy form of hydrogen.

The burst of 20 million amperes of current vaporizes the tungsten wires and generates a magnetic field that accelerates the tungsten vapor toward the center of the cylinder. The vapor slams into the plastic foam, creating a supersonic shock wave. The shock wave generates X-rays that heat the deuterium to more than 20 million degrees Fahrenheit and squeeze it tightly.

In experiments last year, the Sandia researchers first detected telltale neutrons produced by the fusion reactions. They confirmed their findings last month. At present, the thermonuclear explosions are minuscule pops, enough to power a 40-watt light bulb for a mere one

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ten-thousandth of a second. "This is a first step on a long road," Dr. Leeper said.

A \$60 million upgrade to the Z accelerator planned for 2005 will increase the maximum current by a third. Sandia scientists hope for a larger, more powerful machine later. "The physics looks encouraging," said Dr. Dale M. Meade of the Princeton University Plasma Physics Laboratory.

Eventually, to generate electricity, the Sandia scientists envision surrounding the fusion chamber with a liquid that heats up by absorbing the neutrons generated by the fusion reaction. The hot liquid would boil water to turn a turbine.

The Z machine can fire one shot a day. A power plant using the technology would have to include a robotic system that could replace the burned-out tungsten wires, foam and hydrogen capsule every few seconds. Dr. Quintenz said the future plant might be able to produce pulses of energy one trillion times as large as that coming from the Z machine.

Each approach has advantages and disadvantages. Lasers, which can be precisely focused, win the most attention. The \$4 billion National Ignition Facility will fire 192 lasers at one target. Lasers, however, are relatively inefficient. Scientists looking to use heavy elements hope to take advantage of existing technology from particle physics accelerators, using magnets to guide charged particles. The Z machine is relatively energy-efficient and straightforward. "It's a simple technology, really, and it's robust," Dr. Leeper said.

Traditional magnetic-confinement fusion is also moving forward. An international group may build a \$5 billion experimental reactor.

"It's premature to judge which is the winner," said Dr. Stewart C. Prager, a fusion scientist at the University of Wisconsin at Madison. "We definitely need more physics."

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