Could an outlier beat the establishment to fusion power?

Buoyed by recent experimental results, a stealthy company is already making plans to commercialize its aneutronic approach to producing electricity.

A small, private company in southern California appears to have achieved a major milestone on the path to fusion energy: creating a plasma of superheated ions that for an instant remain trapped inside a bottle of magnetic fields. In a carefully orchestrated public debut, the company announced that experiments in which a stable plasma of hydrogen and deuterium was maintained for 5 milliseconds prove that stability can be extended indefinitely as long as sufficient power can be supplied.

Michl Binderbauer, chief technology officer of Tri Alpha Energy, says that the company has tamed all the detrimental instabilities that have stymied researchers who work with devices using a magnetic field arrangement known as field-reverse configuration (FRC). If any instabilities were to occur, he says, they would have arisen within fractions of milliseconds after plasma formation.

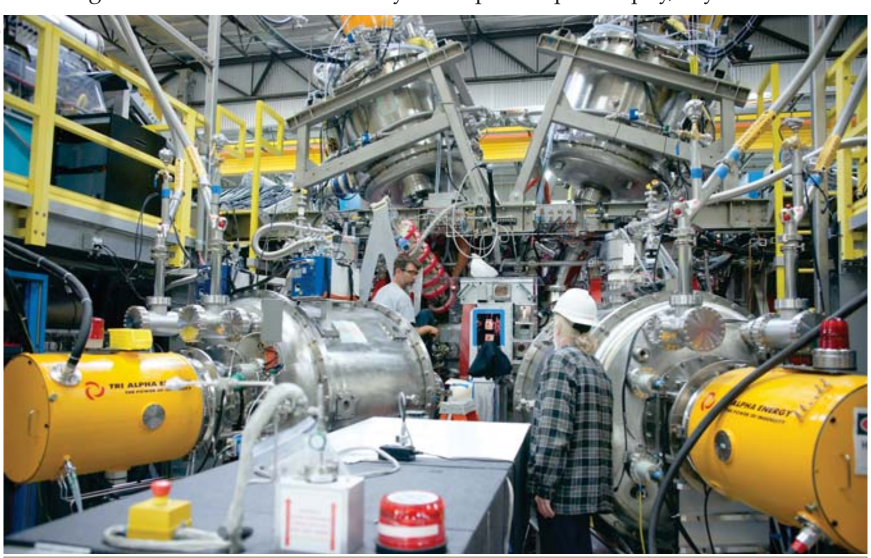
Steven Koonin, a former undersecretary of energy and a member of Tri Alpha's scientific advisory board, agrees. "What they have achieved is rather remarkable and is a demonstrated mastery of FRC," says Koonin, now director of the Center for Urban Science and Progress at New York University.

The FRC technique has generally been regarded by fusion scientists as a less-promising route to fusion than the mainstream approach of tokamak devices. Most of the world's major fusion experiments, including ITER, the massive international reactor under construction in France, are tokamaks, which are toroidal in shape (see related story, page 23, and the article on page 34). Tri Alpha's 23-meter-long C2U reactor is cylindrical.

"At the very ends we make plasmas in two starter chambers," Binderbauer explains. "Think of [the two plasmas] as football-shaped objects. Then we use magnetic peristalsis to accelerate them towards each other. They collide in the central chamber and form a compound larger football with higher energetics, because the kinetic energy turns into heat and makes this hotter object. [The plasma] spins inside, and we inject beams that allow us to sustain the football." The fast particles in the beams supply angular momentum that helps keep the plasma stable.

Failing early

The investor-funded, 150-employee Tri Alpha is driven by a "fail early at the least expense" philosophy, says Binderbauer.



TRI ALPHA ENERGY

Tri Alpha Energy says it has produced a stable plasma in its C2U experimental device. Shown here are the accelerators that supply the beams of particles to help sustain the plasma.

With the recent results in hand, the company is now building a larger apparatus for a three- to four-year experimental program. The new facility will include more beams of around 15 keV to supply the fast particle fuel and energy, says Binderbauer. Tri Alpha's goal is to fuse protons and boron-11, a reaction that, unlike the conventional deuterium–tritium (D–T) combination, will yield few or no neutrons.

The p–^{11}B reaction produces three alpha particles, hence the company's name. But the combination will require temperatures around 3 billion kelvin, far higher than the 100 million to 300 million kelvin needed for D–T. To burn p–^{11}B, Tri Alpha will have to attain a temperature 300 times as hot as the plasma it worked with in the C2U, Binderbauer says. The company's plan to reach such an extreme temperature is aided by the fact that confinement in a beam-driven FRC improves with temperature, the opposite of what occurs in a tokamak, he says.

According to Ronald Davidson, former director of Princeton Plasma Physics Laboratory and a scientific adviser to Tri Alpha, "It was not very long ago that when the FRC configuration was pursued in lab experiments, they were lasting fractions of a millisecond and were highly unstable, certainly not [this] quiescent," he says. Based on what Tri Alpha has done, "one should certainly declare that the approach they are using has been very successful, and the next step is likely to be successful as well."

Tri Alpha's concept requires continuous energy input, unlike the goal of a self-sustaining plasma for a tokamak-based fusion power plant. One question, notes Stephen Dean, president of the industry trade group Fusion Power Associates, is whether the output from a p–^{11}B reaction would exceed the input power by enough to make a power plant economically attractive. Working further against the input–output equation is the fact that p–^{11}B produces about half the energy per reaction as D–T.

Still, Binderbauer is "very confident" that sufficient net power can be achieved to make the fuel cycle attractive for baseload electricity generation. "What remains is to make sure that this is not some super-strange coincidental artifact at the particular design and energetics of the C2U," he cautions, but he says he doesn't believe that is the case. He declines to say whether additional experimental devices will be needed before a commercial plant is constructed.

Tri Alpha does not have a website. The company won't name its investors, but published reports have identified Microsoft cofounder Paul Allen as one. It also won't reveal the full composition of its scientific advisory board, which includes former SLAC director Burton Richter, nor identify all the members of its board of directors, which is chaired by former hedge fund manager and early-stage technology "angel" investor Arthur Samberg. A partial list includes some well-known venture capitalists; former Nuclear Regulatory Commission chair Richard Meserve; and Steven Specker, former chief executive officer of the Electric Power Research Institute.

David Kramer

NSF engineering research centers take on heat and water

New methods for increasing the power density of electric systems used in transportation and more efficient and improved water treatment technologies are the focus of two new engineering research centers announced by NSF in August.

Led by the University of Illinois at Urbana-Champaign, the Center for Power Optimization of Electro-Thermal Systems (POETS) will aim to increase the power density of electrified systems by 10 to 100 times. That increase should lead to lighter, more compact, and more efficient power electronics for cars, airplanes, construction equipment, tools, and other mobile applications. Center researchers will integrate three-dimensional cooling circuitry, power converters, and algorithms to improve power management. Success could lead to a doubling of the range of electric vehicles, according to center officials. The NSF award is valued at $18.5 million over five years.

Andrew Alleyne, POETS's principal investigator, says that while heat dissipation limits power density, thermal considerations are often viewed as a problem to be solved only after the power electronics have been designed. "We take a multidisciplinary approach," he says. "We have electrical engineers, mechanical engineers, materials scientists, and physicists." The objective is to codesign electronics from the beginning to take account of thermal and electric limits.

"It took people who knew computational algorithms and numerical methods, and people who knew semiconductors and chip design, to come up with ways bit by bit to keep climbing up the Moore's law path," he says. "Similarly, we are going to need to have folks