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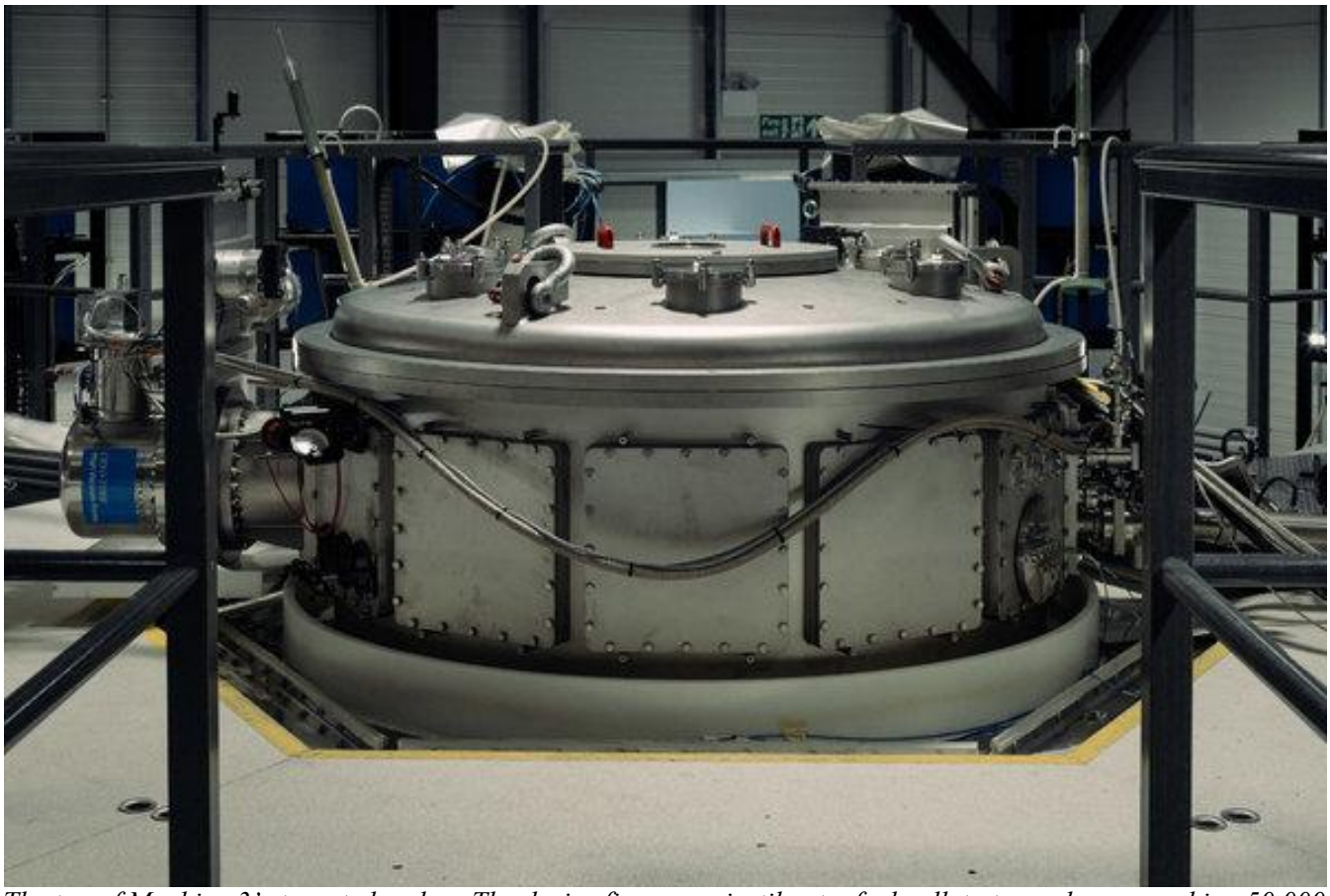


The top of Machine 3's target chamber. The device fires a projectile at a fuel pellet at speeds approaching 50,000 miles per hour. Credit Ben Quinton for The New York Times

The Fusion Reactor Next Door

Entrepreneurs are taking up the search for a near limitless energy source and seeking investors willing to put money behind a long-shot bet against climate change.

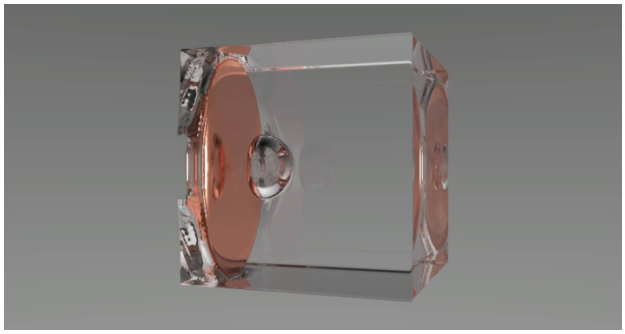
By Stanley Reed, May 13, 2019

YARNTON, England — On a Friday afternoon, a small group of scientists gathered in front of a bank of computer screens near a Ping-Pong table in a warehouse close to Britain's Oxford University. Scattered conversations and laughter hushed as a siren started blaring.

One of the scientists began calling out, "10 … 20 … 30 …," as a hulking machine behind thick walls in the next room was pumped with electromagnetic energy. Within seconds, he gave the command: "Send trigger!"

A sudden bang like a shotgun blast reverberated through the building. The equivalent of hundreds of lightning strikes going off at once had just exploded.

"Well done, everyone," someone said after a few moments, and the chatter resumed. The scientists had just taken another small step toward harnessing the power of the universe, and the weekend beckoned.



In this simulation, a coin-size copper projectile traveling at high speed crushes a fuel pellet of

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hydrogen isotopes contained in clear plastic. The goal is to create the conditions for fusing hydrogen atoms to form helium. Credit Video by First Light Fusion

‘There is no doubt in my mind’

The promise of fusion energy seems fantastic and unapproachable: It is the power behind the sun and the stars. The spark comes when hydrogen nuclei fuse to become heavier atoms. The tremendous burst of energy released in the resulting transformation creates sunlight, and the conditions that enabled our creation. Without it, the universe would be cold, dark and lifeless.

Since the 1930s, scientists have been trying to harness fusion, thinking that it could run the electric power plants of the future and even send people to other planets.

The fusing of hydrogen and helium atoms requires incredible heat and pressure, and for decades fusion research has been the exclusive province of big science, like ITER, a 35-nation thermonuclear project in the south of France that covers 100 acres and is expected to ultimately cost more than $20 billion.

Such initiatives, though, have made slow progress toward the ultimate goal of building a machine that generates more power than it takes in.

Fusion is now attracting science-minded entrepreneurs and investors willing to make a long bet. They see small companies as more nimble than government-funded behemoths. They are sensitive to rising alarms over the impact of climate change. They want to create a power source with enviable possibilities: millions of times the energy potential of oil and gas and substantially more than nuclear power, without the carbon emissions of fossil fuels.

Fusion proponents also say that it is free of most of the risks of contemporary nuclear plants — which are powered by splitting, not joining, atoms — and that it has advantages over wind and solar, whose output is variable and whose turbines and panels require enormous space.

“There is no doubt in my mind that humanity will eventually succeed in making fusion energy happen,” said Robin Grimes, a professor of physics at Imperial College, a public research university in London. “We’ve got no choice.”

Nick Hawker, a founder of First Light Fusion, at the company’s facility outside Oxford, England. “We really need new technologies or else things are going to be very difficult,” he said. Credit Ben Quinton for The New York Times

‘The world’s hardest problem’

In an industrial park outside Oxford, First Light Fusion is challenging some energy orthodoxy. The company was founded eight years ago by Nick Hawker, an Oxford University doctoral student at the time, and Yiannis Ventikos, his thesis adviser. Mr. Hawker, 33, said he was first attracted to fusion because it was “the world’s hardest problem.”

The company’s chief executive, he sees fusion as a way of battling a warming Earth. Solving climate change would require not only huge investments in energy sources like wind and solar, but also a large amount of steady, emissions-free electric power. Fusion, Mr. Hawker said, could fill much of that need.

“We really need new technologies or else things are going to be very difficult,” he said. Instead of working at a university or government lab, Mr. Hawker raised about $30 million from investors, including Oxford University, to take a less-traditional approach.

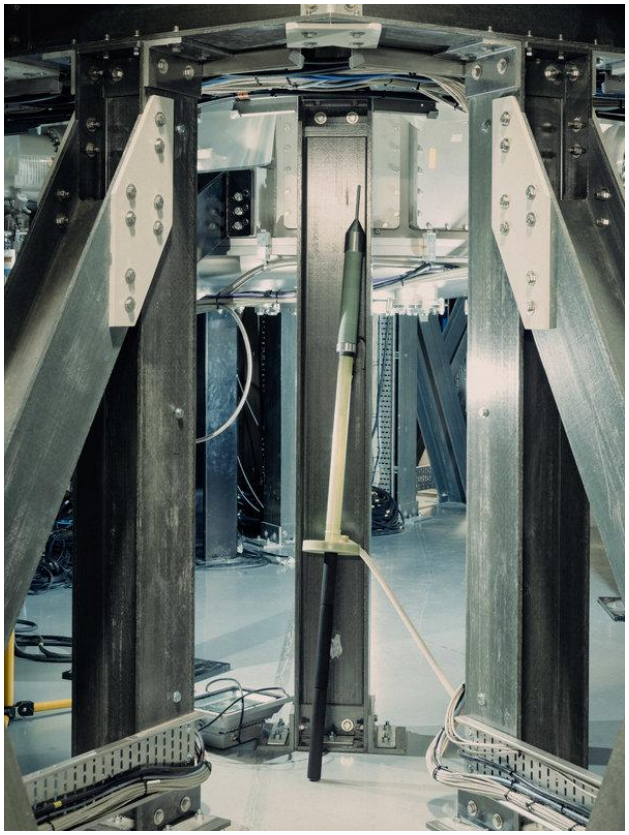
Fusion experiments usually involve superheating a boiling soup of atoms known as a plasma inside a doughnut-shaped contraption called a tokamak. It requires enormous amounts of energy and materials that can withstand temperatures of more than 100 million degrees Celsius.

Instead, Mr. Hawker fires projectiles at a target in tests done about three times a week. Specifically, he shoots disc-shaped bullets the size of a dime at speeds of nearly 50,000 miles an hour at a bead of hydrogen

isotopes encased in clear plastic — a fuel pellet — from just inches away. The collision compresses the pellet and is meant to create the conditions for fusing hydrogen atoms to form helium. In Mr. Hawker's plans, that release of heat, scaled and repeated, will eventually power electricity generating plants.

That is the theory, anyway.

As Mr. Hawker explains his work, First Light's pride and joy, a device 40 feet in diameter and 11 feet high built of blue electrical boxes slotted into a glass-reinforced plastic frame surrounding a steel vacuum chamber, stands waiting. Known as Machine 3, it is the company's bespoke, nearly $5 million would-be fusion reactor, and it keeps about 40 scientists busy. It occupies its own room and fires its projectiles with a ferocious electromagnetic jolt that can reach up to 200 kilovolts and in excess of 14 million amperes — imagine 500 simultaneous lightning strikes — within two millionths of a second.



The underside of First Light's pride and joy, the unit known as Machine 3, and its target chamber. Credit Ben Quinton for The New York Times

Buying in early and cheap

First Light Fusion, one of the few entrepreneurial fusion efforts in Europe, belongs to the 17-member Fusion Industry Association, a trade group for private companies working on the commercialization of fusion.

The association's other members include Tokamak Energy, which is also based near Oxford, and Commonwealth Fusion Systems, a company founded by scientists at M.I.T. in Cambridge, Mass. Commonwealth has received financing from Breakthrough Energy Ventures, a fund led by the Microsoft founder Bill Gates, as well as $50 million from the Italian oil giant Eni. The industry association estimates financing for the entrepreneurial projects — some, like Commonwealth, connected to major research universities — at $1 billion to $1.5 billion.

Innovation is not limited to start-ups. Sandia National Laboratories, in New Mexico, and Lawrence Livermore National Laboratory, in California, are also exploring the use of fuel pellets in fusion reactors.

Paul Holligan, an engineer who helped design Machine 3, said that the group working at First Light moved quickly and that he had "achieved more here in three years than in 20 years" at a top British government laboratory. But the company does not anticipate generating revenue for at least five years, requiring extreme patience from its investors. Revenue is expected from licensing deals and sales of the fuel pellets, which Mr. Hawker considers the company's key technology.

Skeptics contend that fusion may always remain beyond reach. Believers see an opportunity to buy in early and cheap.

"It is not often you come across a whole new way of making clean power," said Robert Trezona, head of cleantech at IP Group. The company invests in university spinoffs and, with a stake of 11 million pounds, or about $14.3 million, is First Light's largest shareholder. "This could be a major industry," he added.

Hugh Sloane, a founder of the investment firm Sloane Robinson, said he admired Mr. Hawker's ambition and attention to detail and how much he had achieved with very little money. Concerns about climate

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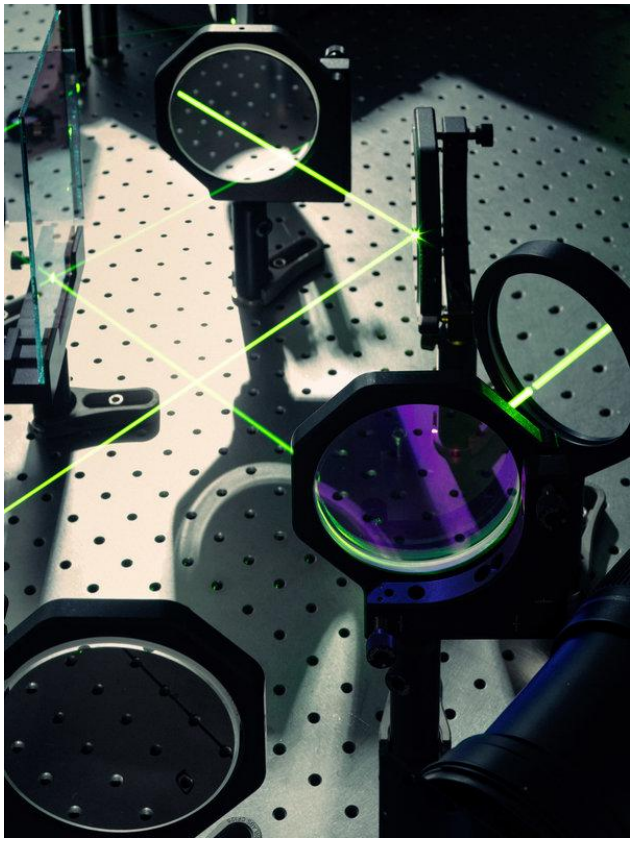
change and the tax advantages of investing in a start-up in Britain drew in his money.

Still, Mr. Sloane said he thought that financial success anytime soon was a long shot. “There is a very healthy element of philanthropic support for pure science,” he said.



Lasers are used to measure the speed of coin-size projectiles fired at a pellet from just inches away. Credit Ben Quinton for The New York Times

Minds, and money

Mr. Hawker hopes to achieve fusion this year and then raise more money for an even more advanced machine. But early models built around his innovations will not be cheap, costing up to $3 billion for a relatively small commercial generator.

Mr. Hawker’s model is based on the idea of how a pistol shrimp moves. The sea creature, by snapping its claws, creates tiny underwater explosions. His machine works by shock and compression, too, he said, and that is much less expensive than other commercial experiments.

Risky as efforts like Mr. Hawker’s may be, physicists running large fusion initiatives welcome the fresh money and brains.

“There are plenty of challenges to getting to a commercial fusion reactor,” said Ian Chapman, chief executive of the Culham Center for Fusion Energy, Britain’s national laboratory for fusion research, “and the more smart people working on those challenges, the better.”

Stanley Reed has been writing from London for The Times since 2012 on energy, the environment and the Middle East. Prior to that he was London bureau chief for BusinessWeek magazine. @stanleyreed12 • Facebook

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