Fusion energy hurdle swept aside

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A major hurdle to producing fusion energy using lasers has been swept aside, results in a new report show.

The controlled fusion of atoms - creating conditions like those in our Sun - has long been touted as a possible revolutionary energy source.

However, there have been doubts about the use of powerful lasers for fusion energy because the "plasma" they create could interrupt the fusion.

An article in Science showed the plasma is far less of a problem than expected.

The report is based on the first experiments from the National Ignition Facility (Nif) in the US that used all 192 of its laser beams.

Along the way, the experiments smashed the record for the highest energy from a laser - by a factor of 20.

Star power

Construction of the National Ignition Facility began at Lawrence Livermore National Laboratory in 1997, and was formally completed in May 2009.

The goal, as its name implies, is to harness the power of the largest laser ever built to start "ignition" - effectively a carefully controlled thermonuclear explosion.

INERTIAL CONFINEMENT FUSION

- 192 laser beams are focused through holes in a target container called a hohlraum
- Inside the hohlraum is a tiny pellet containing an extremely cold, solid mixture of hydrogen isotopes
- Lasers strike the hohlraum's walls, which in turn radiate X-rays
- X-rays strip material from the outer shell of the fuel pellet, heating it up to millions of degrees
- If the compression of the fuel is high enough and uniform enough, nuclear fusion can result

It is markedly different from current nuclear power, which operates through splitting atoms - fission - rather than squashing them together in fusion.

Proving that such a lab-based fusion reaction can release more energy than is required to start it - rising above the so-called breakeven point - could herald a new era in large-scale energy production.

In the approach Nif takes, called inertial confinement fusion, the target is a centimetre-scale cylinder of gold called a hohlraum.

It contains a tiny pellet of fuel made from an isotope of hydrogen called deuterium.

During 30 years of the laser fusion debate, one significant potential hurdle to the process has been the "plasma" that the lasers will create in the hohlraum.

The fear has been that the plasma, a roiling soup of charged particles, would interrupt the target's ability to absorb the lasers' energy and funnel it uniformly into the fuel, compressing it and causing ignition.

Siegfried Glenzer, the Nif plasma scientist, led a team to test that theory, smashing records along the way.

"We hit it with 669 kilojoules - 20 times more than any previous laser facility," Nif's Siegfried Glenzer told BBC News.

That isn't that much total energy; it's about enough to boil a one-litre kettle twice over.

However, the beams delivered their energy in pulses lasting a little more than 10 billionths of a second.

By way of comparison, if that power could be maintained, it would boil the contents of more than 50 Olympic-sized swimming pools in a second.

'Dramatic step'

Crucially, the recent experiments provided proof that the plasma did not reduce the hohlraum's ability to absorb the incident laser light; it absorbed about 95%.

But more than that, Dr Glenzer's team discovered that the plasma can actually be carefully manipulated to increase the uniformity of the compression.

"For the first time ever in the 50-year journey of laser fusion, these laser-plasma interactions have been shown to be less of a problem than predicted, not more," said Mike Dunne, director of the UK's Central Laser Facility and leader of the European laser fusion effort known as HiPER.

"I can't overstate how dramatic a step that is," he told BBC News. "Many people a year ago were saying the project would be dead by now."

Adding momentum to the ignition quest, Lawrence Livermore National Laboratory announced on Wednesday that, since the Science results were first obtained, the pulse energy record had been smashed again.

They now report an energy of one megajoule on target - 50% higher than the amount reported in Science.

The current calculations show that about 1.2 megajoules of energy will be enough for ignition, and currently Nif can run as high as 1.8 megajoules.

Dr Glenzer said that experiments using slightly larger hohlraums with fusion-ready fuel pellets - including a mix of the hydrogen isotopes deuterium as well as tritium - should begin before May, slowly ramping up to the 1.2 megajoule mark.

"The bottom line is that we can extrapolate those data to the experiments we are planning this year and the results show that we will be able to drive the capsule towards ignition," said Dr Glenzer.

Before those experiments can even begin, however, the target chamber must be prepared with shields that can block the copious neutrons that a fusion reaction would produce.

But Dr Glenzer is confident that with everything in place, ignition is on the horizon.

He added, quite simply, "It's going to happen this year."

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