

**PHYSICS**

# NUCLEAR FUSION BREAKTHROUGH BRINGS UNLIMITED CLEAN ENERGY ONE STEP CLOSER

For the first time, the atom-smashing technique has been successfully used to generate more energy than researchers put in

**ABOVE** The target chamber of Lawrence Livermore National Laboratory, where scientists created fusion ignition for the first time

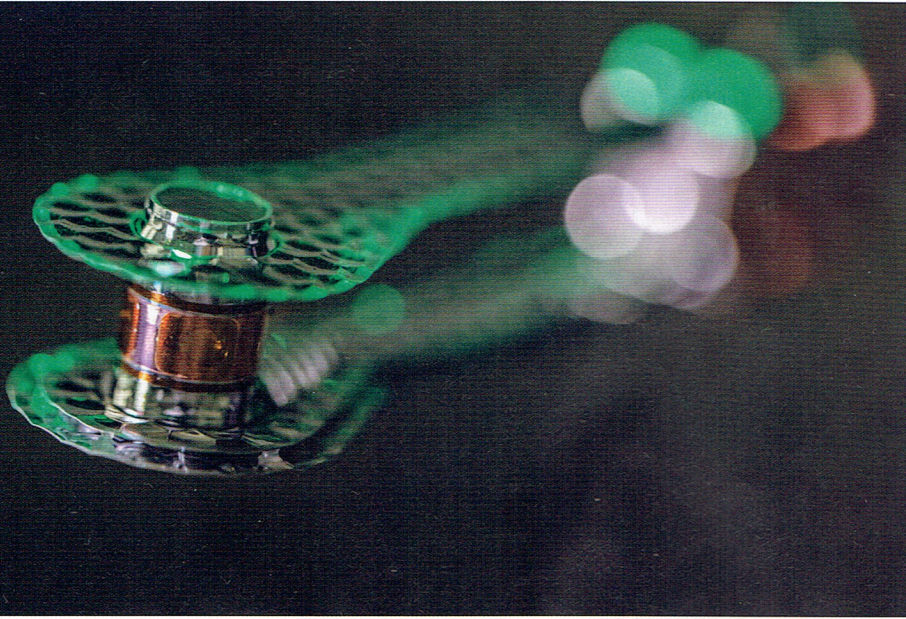
**S**cientists at the National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory (LLNL) in the US have successfully generated a net gain in energy via a nuclear fusion reaction for the first time in history – a phenomenon known as ‘ignition’.

The breakthrough comes after decades of research efforts by scientists all around the globe. It represents a significant step towards a clean, reliable energy source that could one day end humanity’s dependence on fossil fuels.

“The pursuit of fusion ignition in the laboratory is one of the most significant scientific challenges ever tackled by humanity, and achieving it is a triumph of science, engineering, and most of all, people,” said Dr Kim Budil, the director of the LLNL, speaking at a press conference on 13 December 2022.

“Crossing this threshold is the vision that has driven 60 years of dedicated pursuit – a continual process of learning, building, expanding knowledge and capability, and then finding ways to overcome the new challenges

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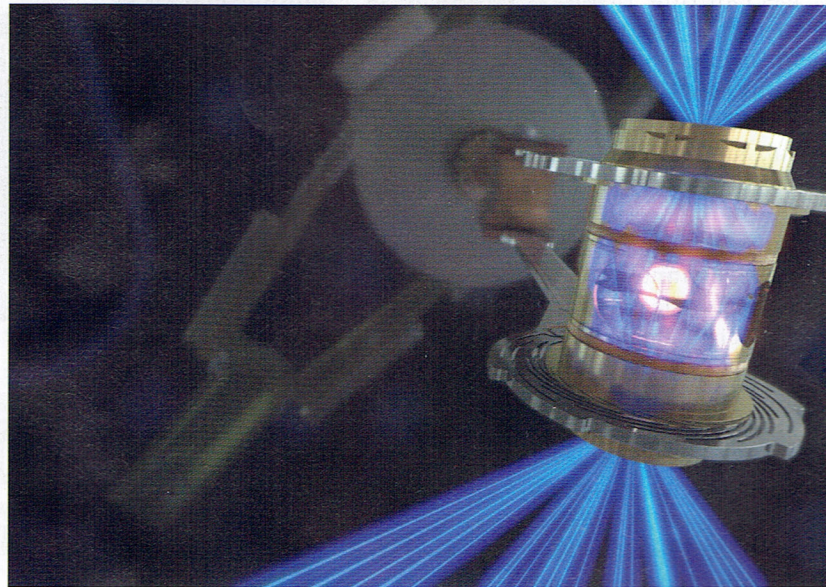
that emerged. These are the problems that the US National Laboratories were created to solve.”

Fusion reactions occur when the nuclei of atoms are forced together by extreme pressures or temperatures. When this force is strong enough to overcome the electrostatic force that repels them, the nuclei are pulled together by the strong nuclear force – one of the forces described by the Standard Model of particle physics. This leads to them being fused together and creating a new, heavier nuclei, with energy produced in the process.

In the case of the NIF, which is the world’s largest and most powerful fusion reactor, the nuclei used were two isotopes of hydrogen: deuterium, which contains one neutron and one proton; and tritium, which contains two neutrons and one proton. These combine to form helium nuclei. As the mass of the helium nuclei is slightly less than the mass of two hydrogen nuclei, this extra mass is released as energy.

The reactor achieves this by shooting nearly 200 energetic lasers into a hollow cylinder called a hohlraum. The hohlraum contains a small spherical capsule of the hydrogen isotopes, the ‘fuel’ for the experiment. This generates an aura of X-rays that triggers an implosion that moves at more than 400km/s. This creates huge pressures and temperatures that cause the hydrogen isotopes to fuse.

In their latest run, the researchers put around 2.05MJ of energy in and got 3.15MJ out – a net gain within the system. However, they had to put 300MJ of energy into the lasers to generate the initial pulse, with only 2.05MJ actually making it to the target – a figure that is still considerably lower than what would be needed to consistently generate electricity. This means that, although the results are promising, we are still a way off from seeing the first nuclear fusion power plant. Still, this represents a significant improvement on the



**TOP** The small, cylindrical hohlraum, into which the hydrogen fuel capsule is placed

**ABOVE** Within the fusion experiment, lasers are fired at the hohlraum, which generates the X-rays that kickstart the fusion process

previous record set by the NIF team in August 2021, when they got 1.3MJ out of an input of 2MJ.

“What the NIF result shows is that inertial fusion can release more energy from fusion than goes into heating the fuel. This is a huge boost for all fusion efforts and will raise ambitions across the board,” said Dr Valerie Jamieson, fusion cluster technology manager at UK Atomic Energy Authority, who was not involved in the research.

“Bear in mind that NIF is an experiment, not a power plant, and its specific approach using 192 high power lasers isn’t commercially viable. That said, this result is important to commercial fusion efforts that are working towards a power plant. There are still challenges to overcome, but we have never been closer to fusion.”