Department of Energy announces successful nuclear fusion ignition

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On Tuesday, a joint press release from the US Department of Energy (DOE) and the department's National Nuclear Security Administration announced that scientists at the National Ignition Facility (NIF) have achieved a controlled nuclear fusion reaction which resulted in a net energy gain. Data from the facility show that 2.05 megajoules (Mj) of input energy—just under 0.6 kilowatt hours—was used to produce 3.15 Mj of output fusion energy.

To produce the results, nuclear physicists at the NIF used 192 spherically arranged lasers aimed at a half-centimeter target vessel containing deuterium and tritium, two heavy variants of the element hydrogen. An extremely brief and powerful pulse of light from the lasers is channeled by the target to produce a symmetrical explosion about the inner hydrogen fuel, imploding and heating it to the extreme conditions where nuclear fusion takes place.

This process, of "burning" hydrogen into helium, powers stars like our Sun over billions of years, but the NIF produces fusion conditions for only 100 trillionths of a second: it reaches temperatures and pressures 10 times higher than those at the center of the Sun to fuse a significant amount of its fuel during that instant, forcing an implosion of the material that ignites the material and starts nuclear fusion, the process through which the Sun and all stars shine.

The achievement is what is known as scientific breakeven, when the energy produced by the implosion is equal to or greater than the energy transferred to the capsule.

The announcement marks one of the major milestones since the NIF was established in 1997. It was developed as an arm of the Lawrence Livermore National Laboratory to study a method of achieving nuclear fusion, known as inertial confinement fusion. Construction was completed in 2009 and NIF has been performing experiments ever since, leading up to this week's results.

One of the major difficulties of inertial confinement fusion is that the lasers must hit the target in an exactly spherically symmetrical pattern, otherwise the precise implosion needed to produce fusion either will not occur or will only produce small amounts of energy. As recently as 2018, the NIF was only capable of producing 54 kilojoules of energy, 58 times less than the most recent results.

A major breakthrough was achieved last year when the scientists developed new techniques to more fully master the symmetries and asymmetries of the system, resulting in an energy yield 25 times greater than the results from 2018. While they at the time had yet to achieve scientific breakeven, the researchers reached 70 percent of that goal. The announcement Tuesday is a further refinement of what was developed last year.

And while scientific breakeven is an important success in the pursuit of controlled nuclear fusion, it is not yet the panacea of clean and abundant energy that will help abate and reverse climate change being presented in the corporate media. There is still a great deal of work to reach what is known as *engineering* breakeven. The main problem is that the lasers used by the NIF are inefficient. Only about 0.5 percent of the total energy powering the lasers is actually delivered to the target to kindle nuclear fusion.

In other words, the energy output needed to really start considering inertial confinement fusion as a power source for industrial, commercial and residential use needs to be more than 240 times what was reported on Tuesday. And that does not include the further efficiency considerations surrounding somehow converting the energy produced into electricity.

Inertial confinement is not generally considered the method upon which a nuclear fusion power plant will be based. The more likely strategy is a tokamak reactor, a word coined by Soviet scientist Igor Golovin in 1957 and which stands for either toroidal chamber with magnetic coils or toroidal chamber with axial magnetic field, depending on the Russian transliteration. The concept uses magnetic fields to confine and compress super-hot plasma into a toroidal (donut-like) shape.

Dozens of tokamak reactors have been built since they were first theorized in the 1950s, each generation built on engineering and physical insights gathered with the previous ones. The drive has been toward larger tokamaks, necessary to increase their efficiency in the drive towards scientific breakeven. But the costs of each generation have been sharply higher. The most successful previous tokamak was the nearly half-billion dollar Joint European Torus (JET), which first operated in 1983 and which still is used in fusion studies. Its most successful experiment occurred just last year, in which it achieved a five second operation producing about one-third the output of scientific breakeven.

The roughly $20 billion tokamak ITER, which is expected to start operations sometime in the next three years, is expected to have a minimum of a six-fold gain in energy production over the NIF result. ITER is an international collaboration that has been in development since 1979 and includes personnel and funding from China, the European Union, India, Japan, Russia, South Korea and the United States. The project has been compared to the Large Hadron Collider and the International Space Station in cost, scale, complexity and ambition.

The successor to ITER, "DEMO," is already under discussion, but the international collaboration which continues in ITER has largely fallen apart under the developing world crisis and the competitive advantages for a nation-state which was able to hold the details of a functional demonstration unit closely. Given that the National Academy of Sciences outlined in 2019 a strategy for continuing development through "private-sector ventures," future costs and timescales are now subordinate to the capitalist system, not driven by scientific planning.

There is also deeply a militaristic aspect to the research at the NIF as compared to tokamak reactors. Nuclear fusion on a vast scale by implosion was achieved in 1952 after President Harry Truman ordered the development of the hydrogen bomb in response to the first atomic bomb test by the Soviet Union in 1949. The only way to achieve the necessary physical conditions to achieve fusion was to use a nuclear fission bomb of the sort dropped on Hiroshima and Nagasaki in 1945 to start the fusion reaction and cause a thermonuclear detonation.

The first full-scale test of such a device was the test "Ivy Mike," a 10.4 megaton explosion. Since then, *uncontrolled* nuclear fusion has been the basis of every fusion nuclear weapon developed.

Further research into and production of these weapons was the reason the Lawrence Livermore facility was established in the first place. Throughout the Cold War, it played a key role in developing myriad nuclear weapons, a role which continues today. The laboratory is also used to maintain and refurbish the nuclear stockpile of the US military.

Alongside this, LLNL conducts a great deal of research into the physical properties of plutonium in order to make better fission bombs to ignite fusion warheads. One such avenue uses the laser array that generates fusion energy to implode plutonium. It is a way to study and refine atomic explosions without detonating nuclear weapons, which is prohibited by numerous international treaties.

Such research makes clear that the real outcome of the recent success at the NIF is not toward new energy sources for general use, but for new and more destructive ways of ending human lives. Research into nuclear fusion energy shows that it can be a powerful tool in ending modern civilization's dependence on fossil fuels, but will only be freely developed towards that end when the subordination of such research to imperialist interests is ended.