Lawrence Livermore National Laboratory

National Ignition Facility and Photon Science

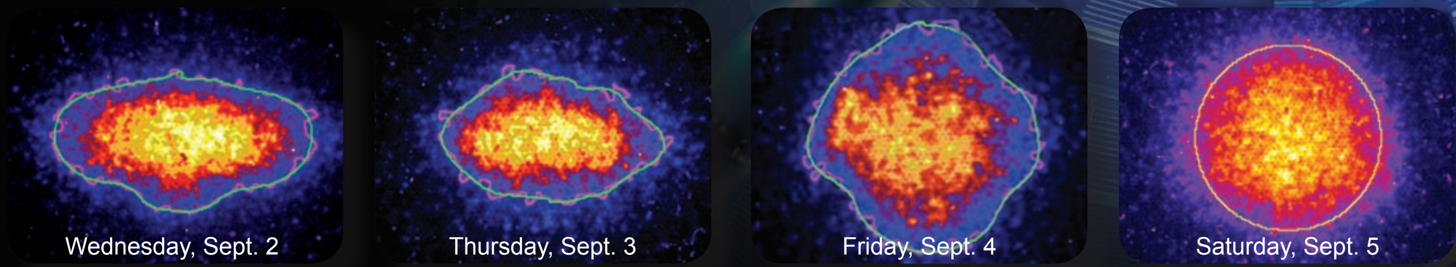
Scientists have been working for more than half a century to achieve self-sustaining nuclear fusion and energy gain in the laboratory. With the beginning of ignition experiments at the National Ignition Facility (NIF), that long-sought goal is now close to realization.

Achieving nuclear fusion in the laboratory is the heart of NIF's three complementary missions: helping maintain the safety, security and reliability of the nation's nuclear stockpile without underground testing; laying the groundwork for clean, safe and abundant fusion energy; and achieving breakthroughs in a wide variety of scientific disciplines ranging from astrophysics to X-ray and neutron science.

As the world's largest and highest-energy laser system, NIF can create temperatures of 100 million degrees and pressures 100 billion times that of Earth's atmosphere—conditions that exist elsewhere only in stars, giant planets and thermonuclear explosions. NIF's 192 laser beams deliver at least 60 times more energy than any previous laser system. By focusing nearly two million joules of ultraviolet laser energy on a BB-sized target in the center of its target chamber, NIF can force the nuclei of deuterium and tritium (two isotopes of hydrogen) to fuse—releasing many times more energy than the laser energy required to initiate the process.

While construction of NIF was a marvel of engineering, the facility also is a *tour de force* of science and technology development. Working closely with industry partners, Laboratory scientists, engineers and technicians found solutions for NIF's optics challenges in rapid-growth crystals, continuous-pour glass, optical coatings and new finishing techniques that can withstand extremely high energies. Other cutting-edge technologies pioneered by NIF include a unique optical switch, sophisticated preamplifiers, deformable mirrors, precision target fabrication techniques, and one of the most innovative and sophisticated computer control systems anywhere in government service or private industry.

NIF was declared operational in March 2009. Initial experiments were conducted in the summer and fall of 2009, and ignition experiments are planned to begin in summer 2010. This experimental program to achieve fusion ignition, known as the National Ignition Campaign, is sponsored by the National Nuclear Security Administration and is a partnership among Lawrence Livermore, Los Alamos National Laboratory, the Laboratory for Laser Energetics, General Atomics, and Sandia National Laboratories, with the participation of numerous other laboratories and universities in the United States and worldwide.



First results from NIF experiments in September 2009 successfully demonstrated the use of wavelength tuning to adjust the shape of the target capsule implosion from asymmetric to spherical, a key requirement for achieving ignition.

Together with two industry partners, LLNL developed a novel continuous melt process for manufacturing the more-than 3,000 meter-sized slabs of ultrahigh-quality neodymium-doped phosphate laser glass needed for NIF.

National Security

NIF is an essential component of the National Nuclear Security Administration's Stockpile Stewardship Program. NIF provides the only platform for scientists to experimentally access and examine the process of nuclear fusion and thermonuclear burn without underground testing. Understanding how the many different kinds of materials used in nuclear weapons behave, especially as they age beyond their intended lifetimes, under the extreme environment produced in a thermonuclear reaction is a key element of the Stockpile Stewardship Program. Data from NIF and other experimental facilities at Livermore and elsewhere will help to inform and validate sophisticated, three-dimensional weapon simulation computer codes and build a fuller understanding of important weapon physics. NIF also will be used to study materials under high-energy-density conditions (that is, under high temperatures and pressures). In addition, NIF's unique capabilities will be applied in experiments of interest to partner agencies in the Department of Defense, such as the effects of high-energy radiation on key national assets, to further basic science relevant to national security.

Energy for the Future

NIF is designed to be the first inertial confinement fusion facility to demonstrate ignition and a self-sustaining fusion burn. In the process, NIF's fusion targets will release 10 to 20 times more energy than the amount of laser energy required to initiate the fusion reaction. By demonstrating the ability to attain fusion ignition in the laboratory, NIF will lay the groundwork for future decisions about fusion's long-term potential as a safe, carbon-free and virtually unlimited energy source.

Success with NIF will set the stage for LIFE (Laser Inertial Fusion Energy), an advanced technology concept for power generation being developed at Lawrence Livermore National Laboratory. LIFE offers many compelling advantages, either as a pure fusion energy source or as one that combines the best aspects of fusion and fission energy systems. LIFE power plants could generate gigawatts of baseload power while avoiding carbon dioxide emissions and mitigating the concerns associated with long-term nuclear waste disposal.

Understanding the Universe

NIF's role in exploring the physics of materials under extreme pressures and temperatures, known as high-energy-density physics, will be unique with the achievement of thermonuclear burn in the laboratory and key to unlocking secrets of the universe. By recreating conditions that exist naturally only in the interiors of stars, supernovas and giant planets, NIF will provide exciting new insights into what happened in the first nanoseconds after the Big Bang and how the fundamental particles of matter coalesced into the stars, the planets and the elements that make life possible. Scientists will be able to study conditions at the cores of massive planets, such as Jupiter, to understand why they are planets and not stars. Research into plasma physics and laser-plasma instabilities will improve our understanding of black holes and supernovas. Other NIF programs promise breakthroughs in the use of lasers in medicine, hazardous waste treatment, particle physics and X-ray and neutron science.

For more information, contact the LLNL Public Affairs Office, P.O. Box 808, Mail Stop L-3, Livermore, California 94551 (925-422-4599) or visit our website at www.llnl.gov.

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