

On the Frontier of Knowledge and Discovery

Lawrence Livermore National Laboratory's (LLNL's) Physics Division conducts leading-edge research and development activities to anticipate and address national needs in the twenty-first century. Our work is focused on applied physics, condensed matter physics, fusion energy science, and high-energy-density (HED) science. Research topics span astrophysics, planetary science, and atomic and plasma physics. The Division's activities also include development of advanced science and technology in the areas of optics, imaging systems, x-ray optics, detectors, accelerators, materials at extreme conditions, equations-of-state, quantum simulations, lasers, space, and fusion. Theoretical and experimental research thrusts are tightly coordinated to provide predictive, validated, comprehensive solutions to national science and technology needs.

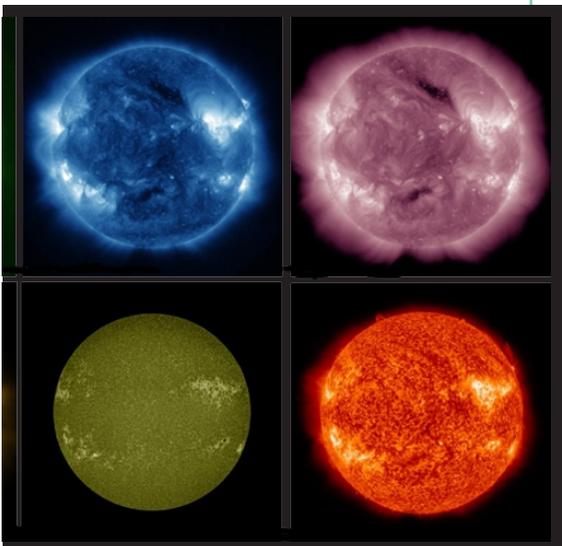
Everything we do supports Laboratory missions in:

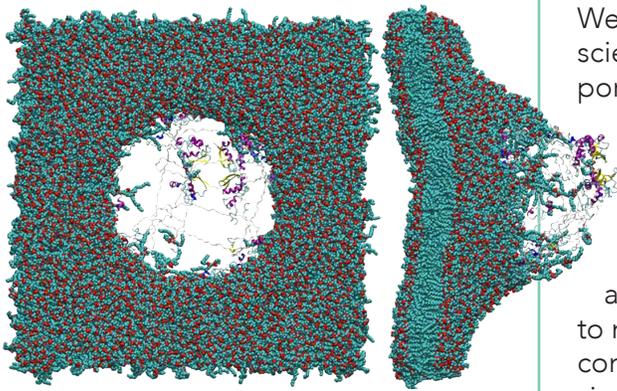
- Foundational science
- Defense technology
- Stockpile stewardship
- Space science and security
- Nuclear threat reduction

## APPLIED PHYSICS

Our scientists and engineers push the boundaries of photon sciences and space technology to meet nuclear security, space security, and basic and applied sciences needs. Our pioneering instrumentation and analysis techniques help establish new approaches for space situational awareness and space-based Earth observations. Our work on visual to x-ray instrumentation as well as laboratory astrophysics plays an important role in telescope and satellite missions and astrophysical investigations. In addition, we pioneer and refine x-ray optics to understand photon-matter interactions and support HED physics efforts at NNSA facilities, while exploring novel uses of multilayer optics for gamma-ray spectroscopy and thermal-neutron imaging.

LLNL optics technology aids exploration of galaxies, supernova remnants, cometary and planetary atmospheres, and stellar/solar coronae. These images of the sun at different extreme ultraviolet (UV) and UV wavelengths as observed by the Atmospheric Imaging Assembly onboard NASA's Solar Dynamics Observatory, using LLNL mirrors, are courtesy of NASA/Lockheed Martin Space and Astrophysics Lab.





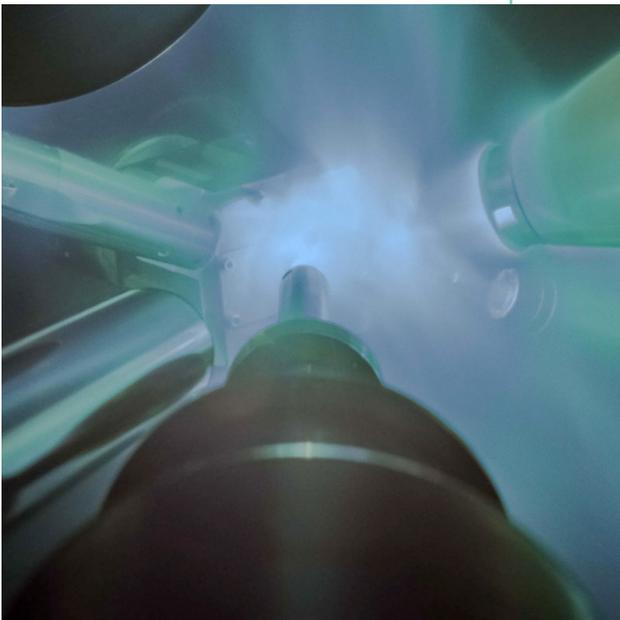
Molecular dynamics simulations help researchers examine the effects of shockwaves, such as a piston velocity of 1000 meters/second on a membrane-bound ion channel.

## CONDENSED MATTER

We conduct forefront research in condensed matter physics, science, and technology in support of LLNL missions. Our portfolio addresses national security, HED science, equations-of-state and constitutive properties, basic science, and advanced technology. Modern experimental platforms, high-performance computing, and advanced theoretical methods are among our key capabilities. We study high-pressure states and dynamics of matter at the Advanced Photon Source. New algorithms and approaches are implemented on supercomputers to model and simulate the behavior of matter under extreme conditions. Using tightly coordinated theory, experiments, and simulations, we explore comprehensive predictive understandings of the physics of matter under a broad range of conditions. From materials theory to phase-transition kinetics, our scientists pursue forward-looking research studies to anticipate future challenges.

## FUSION ENERGY SCIENCE

Covering a broad range of research activities, including magnetic fusion energy, discovery plasma science, HED laboratory plasmas, and fusion technology and materials, the Fusion Energy Science section is LLNL's point of contact for DOE and national fusion programs, and we collaborate with all the major DOE magnetic fusion facilities. Our scientists hold leadership roles in multi-institutional fusion research centers as well as in magnet design for the ITER tokamak. Other international efforts include experiments and modeling in support of fusion energy programs in Europe, China, and South Korea. We provide expertise and support for national security applications of electromagnetic modeling and pulsed-power driven fusion.



LLNL's laser-driven shock compression experiments enable studies of fundamental properties of elements at high pressures and temperatures, such as this one inside the OMEGA Laser Facility target chamber.

## HIGH-ENERGY-DENSITY SCIENCE (HEDS)

Our research in HED physics includes astrophysics, atomic physics, spectroscopy, radiation transport, planetary science, and advanced diagnostic development and supports major LLNL programs. Using dynamic compression techniques and advanced diagnostics, we explore the behavior of matter at high-atmosphere pressures and at high temperatures.

We reproduce the physical states existing inside stars, planets, and nuclear weapons. Ongoing work includes laser-plasma interactions, particle acceleration, harmonic generation, short-pulse laser physics, and magnetic fusion. We explore inertial confinement fusion and weapons physics at the National Ignition Facility. We carry out our HEDS work at major national and international facilities, ranging from synchrotrons and free electron x-ray lasers to z-pinch and laser plasmas. We develop and apply theoretical and computational models to questions of atomic physics, statistical physics, radiation opacities, HED plasmas, laser-matter interactions, and transport.