Space Science and Security

Support of national security and science space missions.

Securing the Heavens

Space science has a rich tradition at Livermore, where scientists study the origin of the solar system, the astrophysical dynamics at play in the Milky Way, and the cosmological evolution of our universe. This research is enabled by combining observational astrophysics, cosmochemistry analyses, novel instrumentation, physics-based modeling and simulation, and multi-disciplinary teams formed from experts in the physical sciences and engineering disciplines. We are applying these capabilities, along with all-source intelligence analysis, to address emerging challenges for the U.S. in the national security space domain.

The urgency of this new mission for LLNL stems from: increasing commercial competition from internal firms; aggressive behavior from countries developing counter-space capabilities; and a more complex global security environment that requires more data to keep decision-makers informed.

LLNL's expertise, infrastructure, and tools created for fundamental space science and core Laboratory missions are delivering new national security space solutions. Innovations include new designs for imaging payloads, optimizing satellite architectures, demonstrating affordable space-based space situational awareness, and developing a government-owned architecture for nanosatellites ("CubeSats").

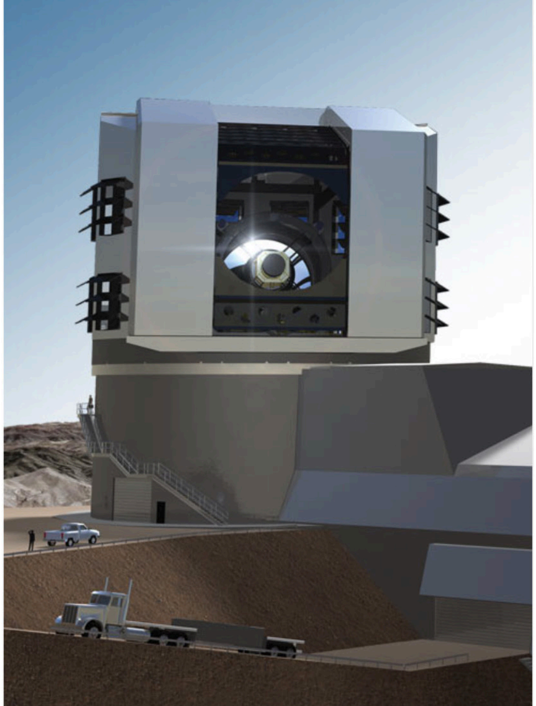
Accomplishments

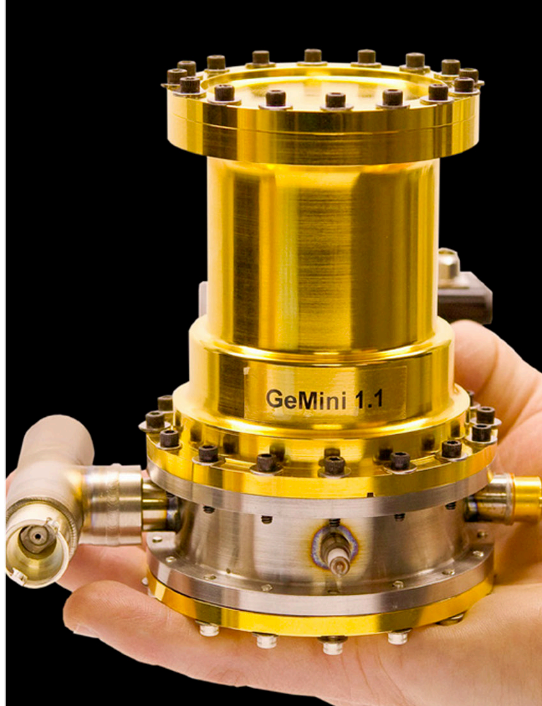
Livermore has made seminal contributions to space science, including:

- Using the Electron Beam Ion Trap and pioneering laboratory-based astrophysics measurements to support several missions for NASA, the European Space Agency, and the Japanese Space Agency.
- A gamma-ray spectrometer for MESSENGER, a NASA mission launched in 2004, that resulted in the first spacecraft to orbit Mercury.
- Starting in the mid-2000's, providing scientific leadership and enabling technologies for the CERN Axion Solar Telescope, a leading particle astrophysics experiment searching for Dark Matter.
- The first images of an extrasolar planetary system in 2008.
- X-ray optics for NASA missions, including the Solar Dynamics Observatory (SDO, 2010) and the Nuclear Spectroscopic Telescope Array (NuSTAR, 2012).
- The Gemini Planet Imager, a powerful ground-based adaptive optics instrument that enables direct imaging and spectroscopy of planets around nearby stars.
- Developing and refining all known isotopic chronometers that yield ages of planetary materials ranging from the first condensates to form in the solar nebula, to rocks from the Moon, and rocks from Martian meteorites.

Expanded efforts include technology development for potential space security missions, including:

- Nano-engineered foils and diffractive optical elements for large lightweight optics.
- Compact, robust optical imaging systems based on a "monolithic" optics concept that combine multiple mirror surfaces into a single structure.
- The creation of a government-owned architecture for nanosatellites, sometimes referred to as "CubeSats."
- Livermore scientists helped develop optical design, lenses and mirror fabrication, and computational methods to analyze the expected 20-terabyte/night flow of data from the Large Synoptic Survey Telescope (LSST) under construction in Chile, which will perform the most comprehensive astronomical survey ever starting in 2021.





Scientific Underpinnings

The Laboratory's growing national security program relies on three symbiotic elements:

1. All-source intelligence analysis—employed to anticipate and respond to emerging threats. Laboratory analysts work in multidisciplinary teams to assess and evaluate technologies using physics-based modeling and simulation and to understand their impact on the security environment.

2. Advanced modeling and simulation tools—used to quickly study and improve potential mission concepts. The Laboratory's scientists and engineers use commercially available, open-source and custom-written codes to understand and optimize the performance of sensors, satellites, and constellations of satellites.

3. Novel instruments—developed to meet mission requirements tailored to small satellite platforms and distributed space operations. Small satellite platforms have multiple virtues, including resiliency, faster technology refresh, and lower risk. In addition, constellations of small satellites offer a pathway towards high-cadence observations, which represents a potential game-changing capability for both space situational awareness (SSA) and intelligence, surveillance, and reconnaissance (ISR) missions.

Many of Livermore's core competencies are used across the entire portfolio of space science and space security projects.

- High resolution x-ray spectroscopy, atomic and nuclear physics, as well as chemical and isotopic science. These disciplines provide the experimental basis to help scientists better understand astrophysical observations and to analyze sample returns from space missions.
- High-performance computing plays an important role in modeling the performance of instrumentation during the design phase, and the basics physics of astrophysical phenomena. Key to our success in this area is applying methods and techniques from Stockpile Stewardship to the broadest set of challenges.
- Advanced manufacturing helps Livermore researchers develop new ways of making essential parts.
- Laboratory expertise required for the nuclear non-proliferation mission are also used to develop technologies to sense and measure x rays, gamma rays, and other radiation.

The Future

LLNL will demonstrate new data analytics and instruments for improved space situational awareness. Building on the successful operation of monolithic optics from space we will explore new form factors and design principles, as well as how such technologies can deliver affordable, persistent, space-based imagery.

The Laboratory will address fundamental questions in planetary science, astrophysics, and cosmology, delivering gamma-ray spectrometers for two upcoming deep-space planetary missions (Psyche and Mars Moon Exploration). We will characterize non-traditional stable isotopes to determine the nucleosynthetic sources that combine to form planets. We will develop x-ray optics and detectors for future satellite missions and provide scientific leadership for the X-Ray Imaging and Spectroscopy Mission. As we lead LSST scientific investigations to elucidate the nature of Dark Energy, we will also apply LSST technologies to the Wide-Field Infrared Survey Telescope.

Principal Sponsorship

- DOD, the U.S. intelligence community, NASA, DOE/NNSA, and DOE/SC

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